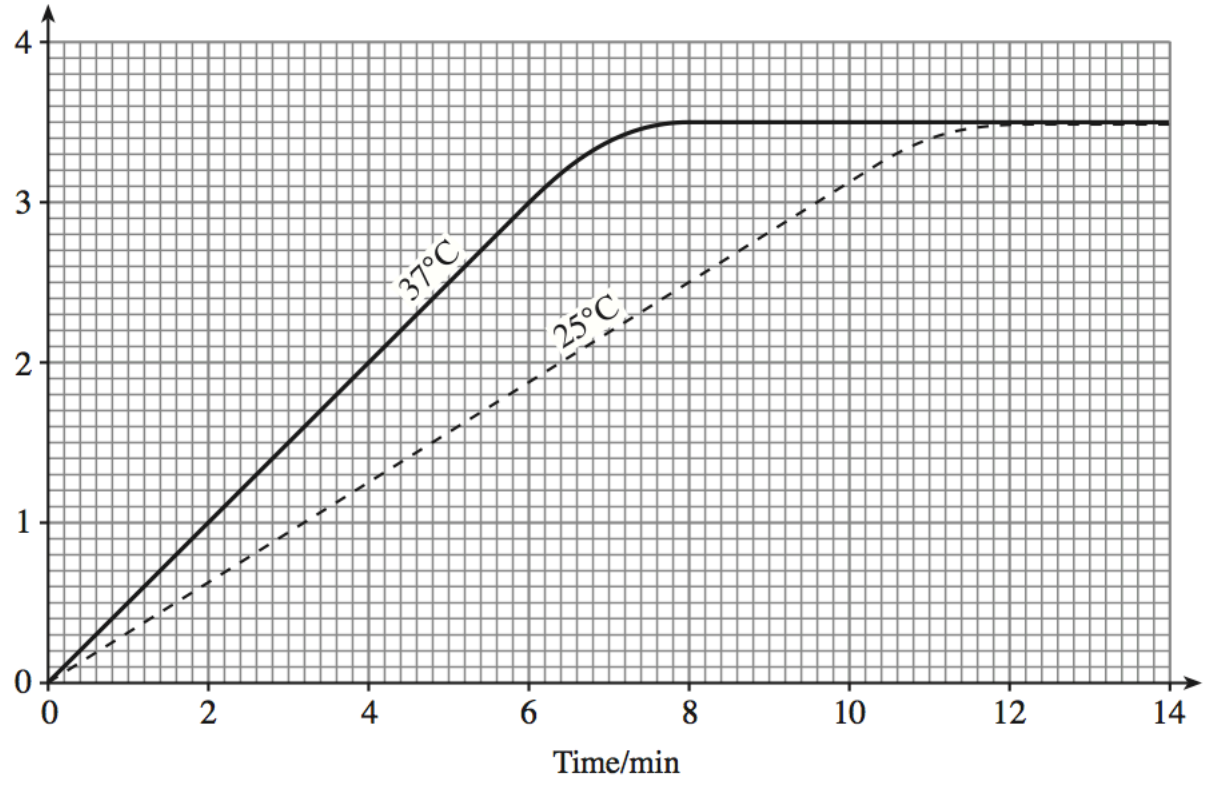
1.

Amylase is an enzyme that catalyses the breakdown of starch into maltose.
Experiments into the action of amylase were carried out. Equal volumes of starch solution and enzyme were mixed.
Two experiments were carried out one at 25°C and one at 37°C.
The quantity of maltose produced was measured and the results plotted as a graph.



(a) (i) Use your knowledge of enzymes to explain the differences between the two graphs. [4]

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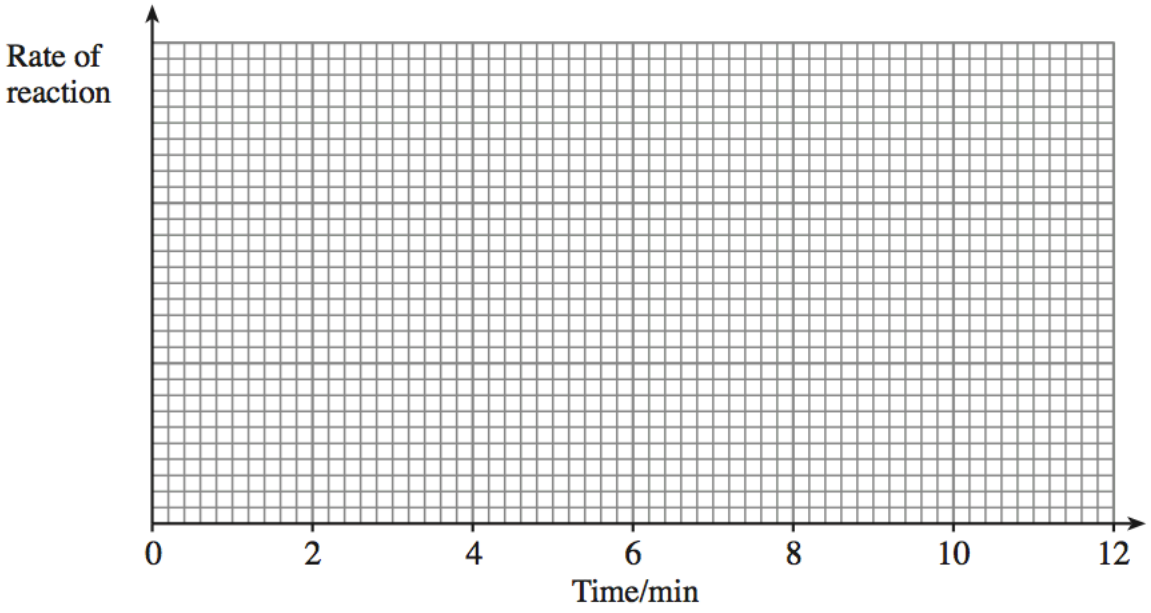
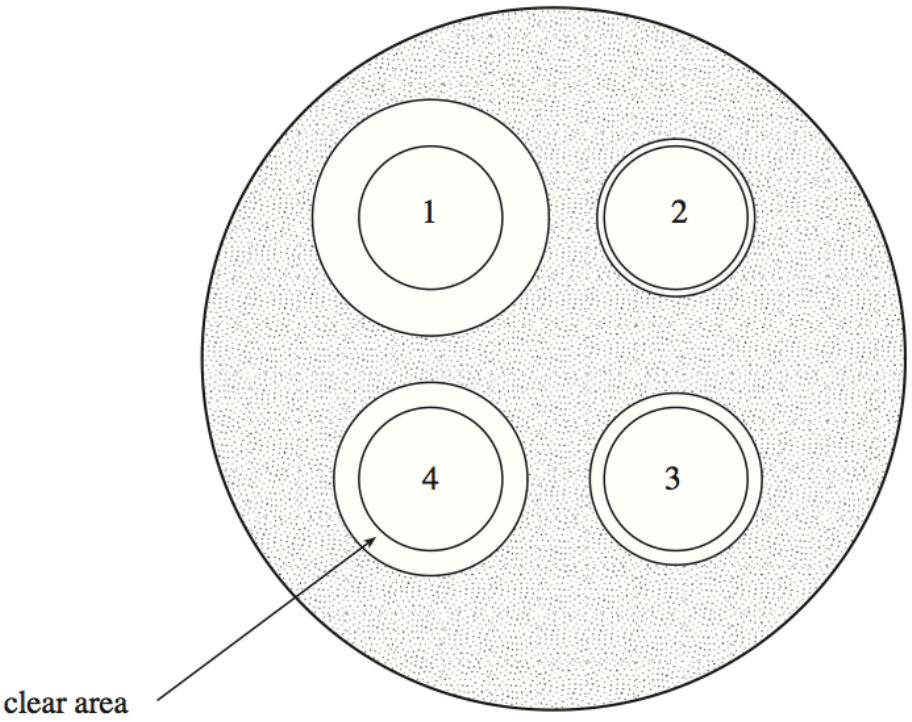
(ii) On the graph below, draw a line to show the rate of reaction for the enzyme at 37°C. [2]



(iii) State **one** *other* factor that could have affected the rate of reaction of the enzyme at 37°C. [1]

.....

(b) Biological washing powders contain enzymes. An investigation using biological washing powders was carried out in which milk protein was mixed with agar jelly in a Petri dish.
Four wells (1- 4) were cut into the agar and each well was filled with a solution of a different washing powder.
The dish was placed in an incubator at 30°C for 24 hours. The results are shown in the diagram below, the clear area around each well shows where the milk protein has been digested.



(i) State which powder was the most effective at digesting milk protein. [1]

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(ii) Explain fully why manufacturers of biological washing powders recommend that these powders are not used at high temperatures. [3]

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(iii) Suggest why it would be incorrect for a manufacturer to claim that the powder identified in *(b)*(i) is the best biological washing powder, based on these results. [2]

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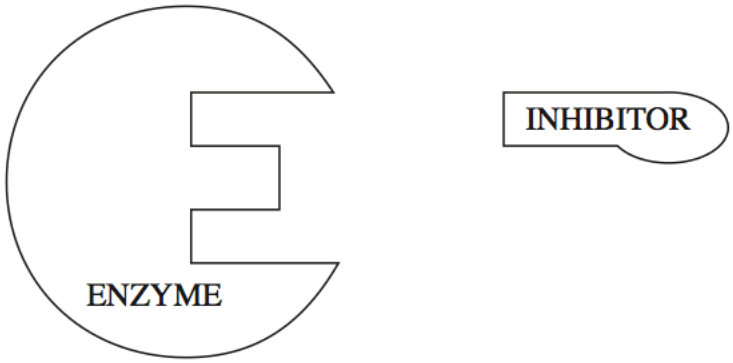
(Total 13 marks)

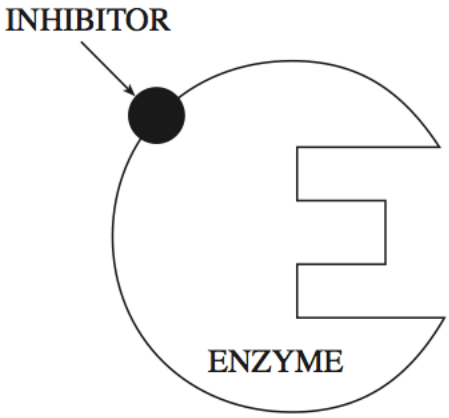
2.

(a) Diagrams **A** and **B** represent two different types of enzyme inhibition.

A.



B.



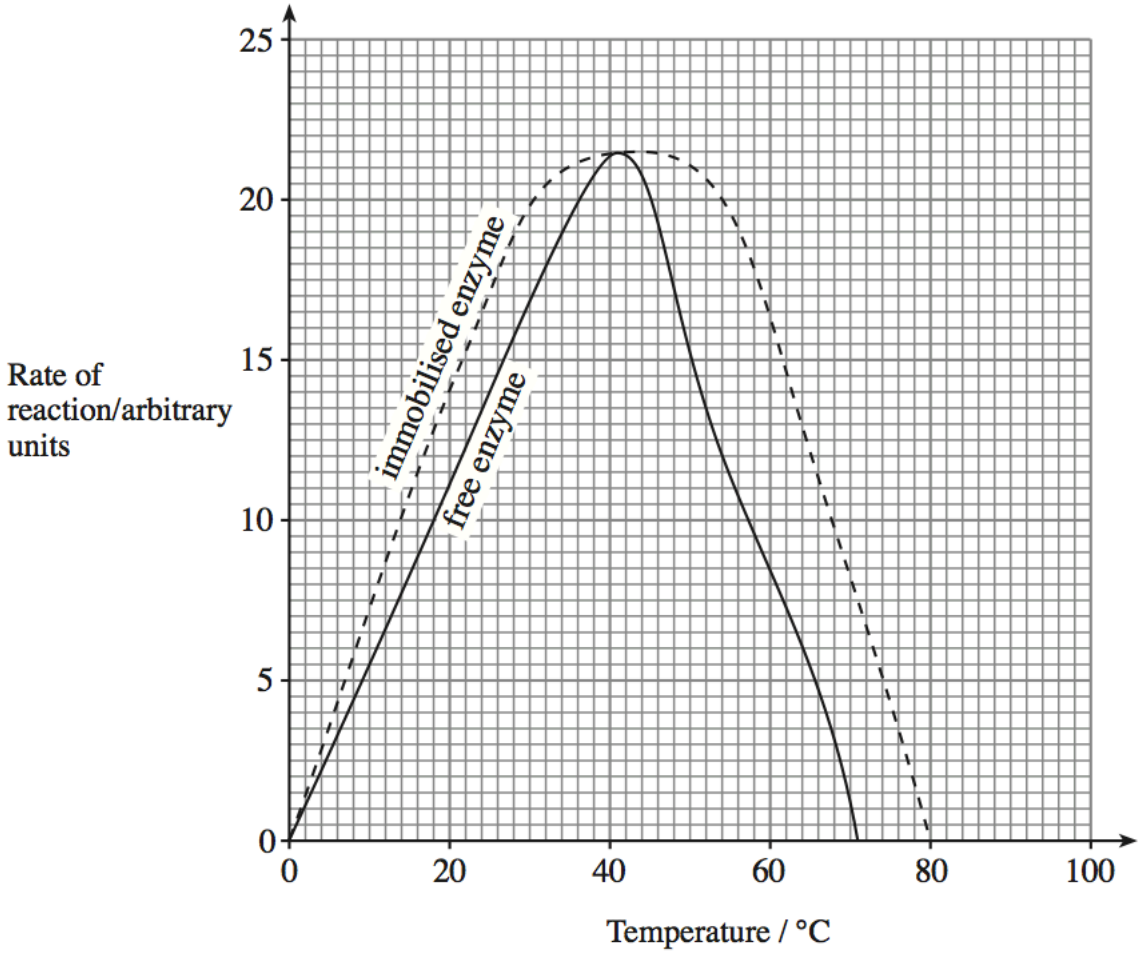
(i) State the type of inhibition shown in **A** and **B**. [2]

A .....

B .....

(ii) What type of inhibition, **A** or **B**, would be **decreased** by increasing the concentration of substrate? [1]

(b) Immobilised enzymes are enzyme molecules that are trapped on an inert matrix such as a gel capsule.
The graph shows the effect of temperature on the maximum rate of reaction of the **same** enzyme in its free and in its immobilised state.



(i) Explain the rate of reaction at 5°C and 70°C for the **free** enzyme. [2]

5°C .....

.....

70°C .....

.....

(ii) Describe **three** differences between the effects of temperature on the immobilised and the 'free' enzyme. [3]

1. .....

.....

2. .....

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3. .....

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(iii) Suggest how trapping the enzyme to an inert matrix can explain the differences you have described in part *(b)* (ii). [1]

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(iv) Describe **one** use of immobilised enzymes in medicine. [1]

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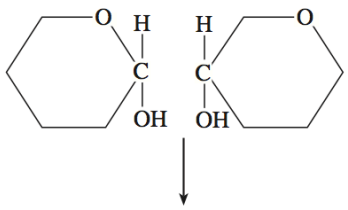
(Total 10 marks)

3.

(a) (i) Complete the diagram to show the reaction between two molecules of glucose and the products formed. [3]



(ii) Name the organic molecule formed. [1]

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(iii) Name the inorganic molecule released during the reaction. [1]

.....

(iv) Name the type of reaction. [1]

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(b) One species of bacterium *Streptococcus mutans* produces the enzyme glucosyl transferase that catalyses the polymerisation of glucose molecules. Polymers of glucose form part of the plaque on teeth which leads to dental disease.

(i) What is polymerisation? [1]

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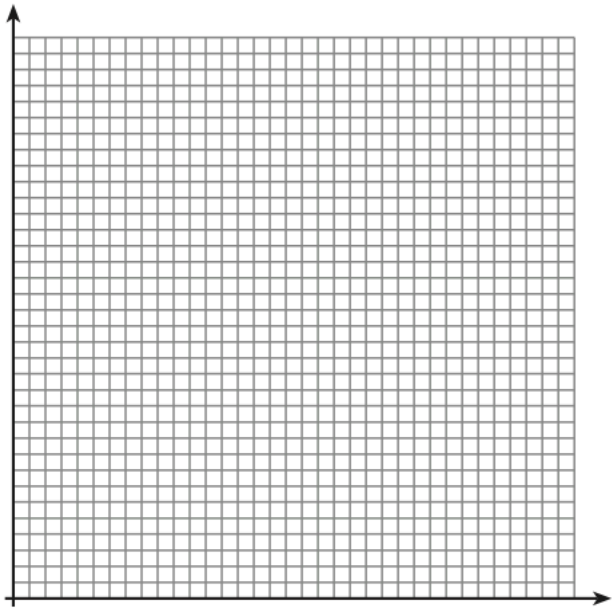
(ii) Two scientists, Devulapalle and Mooser carried out experiments using the enzyme glucosyl transferase and found that its activity was affected by the presence of iron sulphate. They published the following results.

Iron II sulphate concentration (mM)	*glucosyl transferase activity (labelled product µmoles)*
0.0	60.0
1.0	25.2
2.0	12.0
3.0	5.2
4.0	2.4
5.0	1.6
6.0	1.2

(J Dent Res 80: 466-469, 2001)

Plot the data as a suitable graph on the grid provided. [3]



(iii) Use the graph to calculate the concentration of iron sulphate that would decrease the activity of the enzyme by 50%. [1]

.....

(iv) Calculate the percentage by which a 3mM iron sulphate solution would decrease the activity of the enzyme. Show your workings. [2]

Answer .....

(v) Devulapalle and Mooser discovered that the iron sulphate acted as a competitive inhibitor. Describe the mechanism by which competitive inhibitors decrease the activity of enzymes. [3]

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(vi) Suggest a possible use for the discoveries made by Devulapalle and Mooser. [1]

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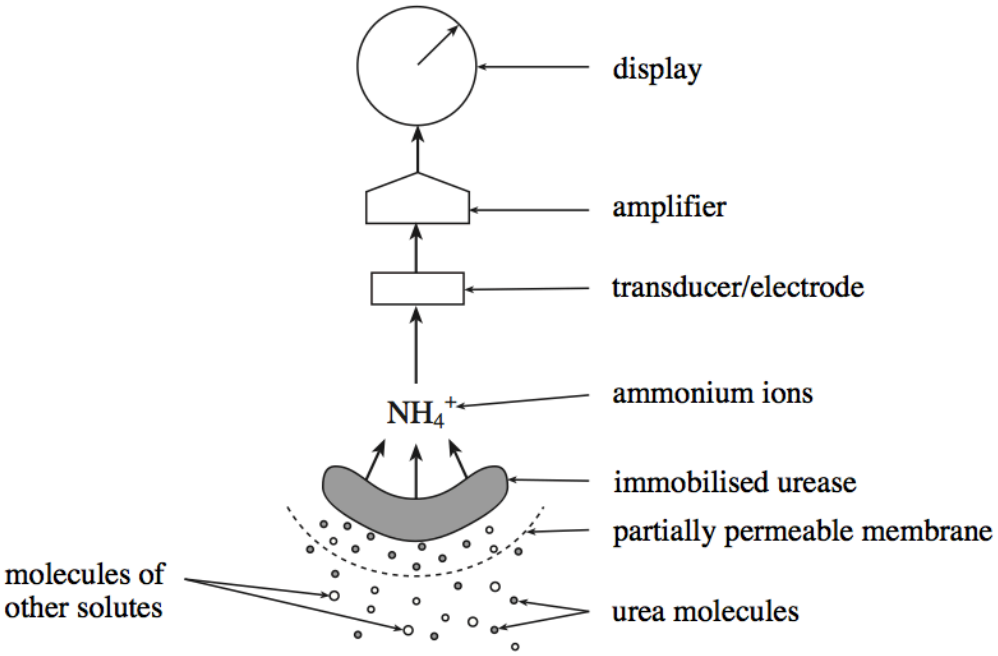
(Total 17 marks)

4.

The diagram below shows a biosensor that uses the enzyme urease to measure urea in either the blood or urine.



(a) (i) Name **one** method that could be used to immobilise the urease. [1]

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(ii) State **three** advantages of using immobilised enzymes. [3]

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(b) (i) Describe the function of the partially permeable membrane in this biosensor. [2]

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(ii) With reference to the diagram, describe the role of this transducer. [2]

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(c) If the biosensor was used to test two blood samples, explain why the temperature of the two samples should be the same. [2]

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(d) Name a medical condition which a biosensor can detect. [1]

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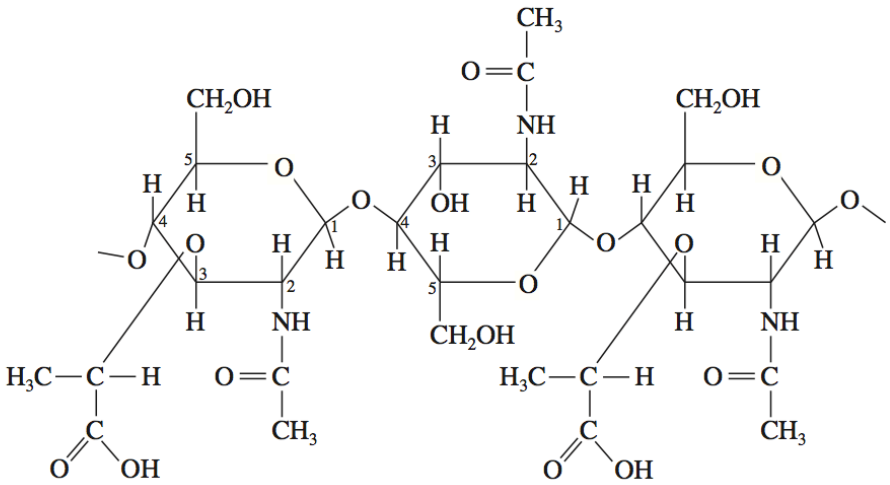
(Total 11 marks)

5.

Heteropolysaccharides consist of long chains of monosaccharides. Each monosaccharide is attached to a non-carbohydrate part.
Bacterial cell walls are made from a heteropolysaccharide consisting of two different monosaccharides – abbreviated to NAG and NAM.
The linear polymer is made up of alternating NAG and NAM molecules, linked by glycosidic bonds.
These chains are arranged in the same way as cellulose of plant cell walls.
The glycosidic bonds can be broken by the enzyme lysozyme.



(a) (i) Draw a circle around the part of **one** of the monosaccharide units that is 'non-carbohydrate'. [1]

(ii) On the diagram, draw an arrow labelled **B** to show a bond which could be broken by the enzyme lysozyme. [1]

(iii) Name the type of reaction involved in the breaking of the bond. [1]

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(iv) Explain what is meant by the phrase 'arranged in the same way as the chains in cellulose'. [3]

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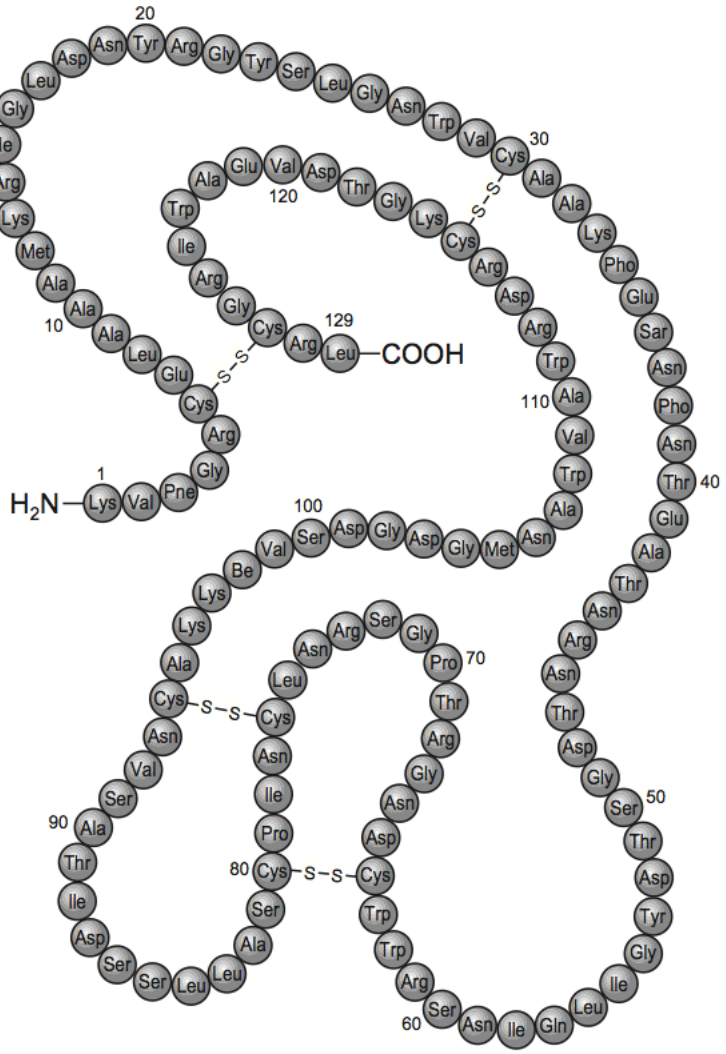
(b) The diagram shows a molecule of the enzyme lysozyme.



(i) State the highest level of protein structure shown in the diagram. [1]

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(ii) Explain the importance of the –S–S– linkages to the functioning of the enzyme. [3]

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(c) Catalase is an enzyme which breaks down hydrogen peroxide into water and oxygen. Hydrogen peroxide is a highly toxic waste product of metabolism.
An investigation was carried out to determine the relative amounts of catalase in samples of potato, liver and apple. The samples were ground to a pulp and added to hydrogen peroxide in measuring cylinders. The table shows the height of the resulting bubbles in the cylinders.

Sample	*Height of bubbles / cm^3*
Potato	4
Liver	9
Apple	1

(i) State **two** variables that should be controlled during this investigation. [2]

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(ii) From the table, liver contains the most catalase. Suggest an explanation for this result. [2]

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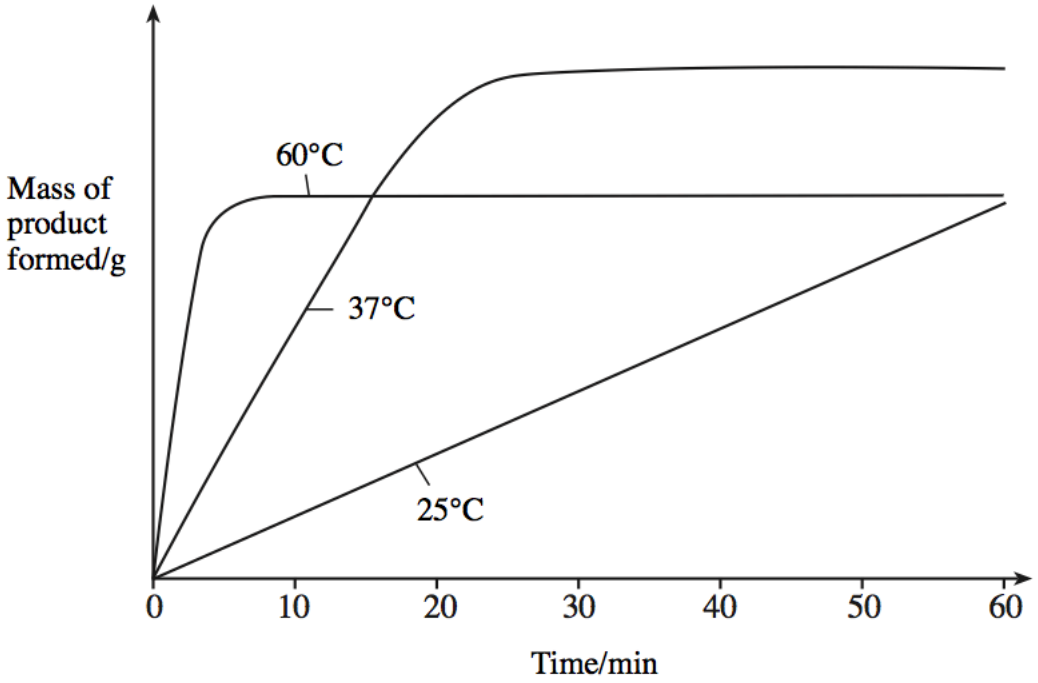
(Total 14 marks)

6.

The graph shows the mass of product formed when a fixed concentration of enzyme is added to a fixed concentration of substrate and then placed in water baths at three different temperatures.



(a) (i) Explain why the mass of product formed at 60°C is greater during the first five minutes than the masses formed at 25°C and 37°C. [3]

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(ii) Explain why there is less overall product formed at 60°C than at 37°C. [3]

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(b) Explain why the mass of product formed at 37°C levels off after approximately 20 minutes. [1]

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(c) Explain why the curve at 25°C has not levelled off after 60 minutes. [3]

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(Total 10 marks)

7.

The presence of glucose in a person's urine is an indication of diabetes. Glucose can be detected by placing, into a sample of urine, a coloured plastic strip containing the immobilised enzyme, glucose oxidase. The strip changes colour if glucose is present.

(a) (i) Describe **two** advantages of using immobilised enzymes. [2]

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(ii) Explain why this diagnostic method is not suitable for the accurate measurement of the concentration of glucose in the urine. [2]

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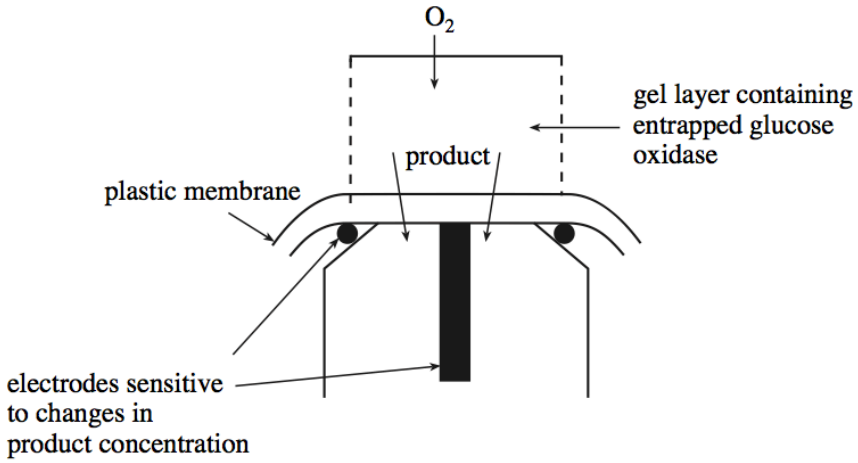
(b) Another method used to measure glucose involves the use of a biosensor.
The diagram below shows an enzyme electrode from a glucose biosensor.



(i) Explain what is meant by the term *biosensor*. [2]

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(ii) Describe the function of the enzyme. [2]

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(iii) Describe how this biosensor can be used to measure blood glucose concentration. [4]

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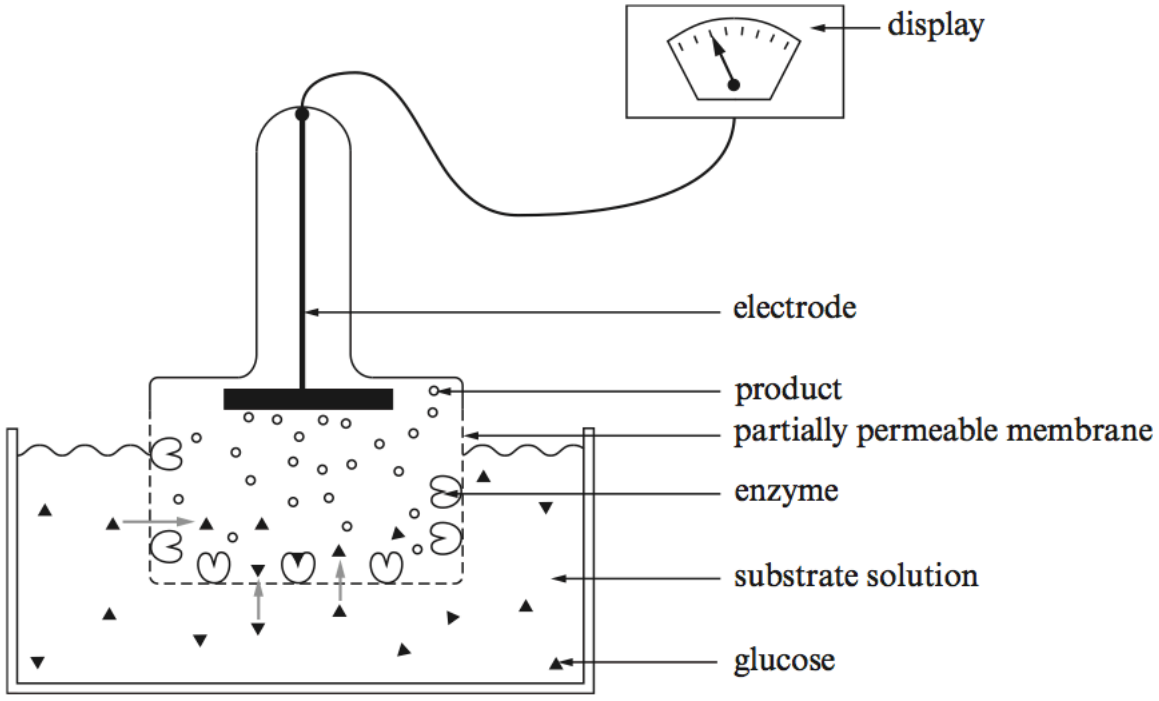
(Total 12 marks)

8.

The diagram below shows a possible structure for a biosensor that uses enzymes to detect glucose.



(a) Immobilised enzymes that are used in biosensors must have certain properties. Suggest **two** of these properties. [2]

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(b) Explain the function of the partially permeable membrane. [2]

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(c) Describe how the concentration of glucose is transmitted to the display. [2]

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(d) Explain why the temperature of the biosensor should be kept constant when using it to measure the concentration of glucose in different solutions. [2]

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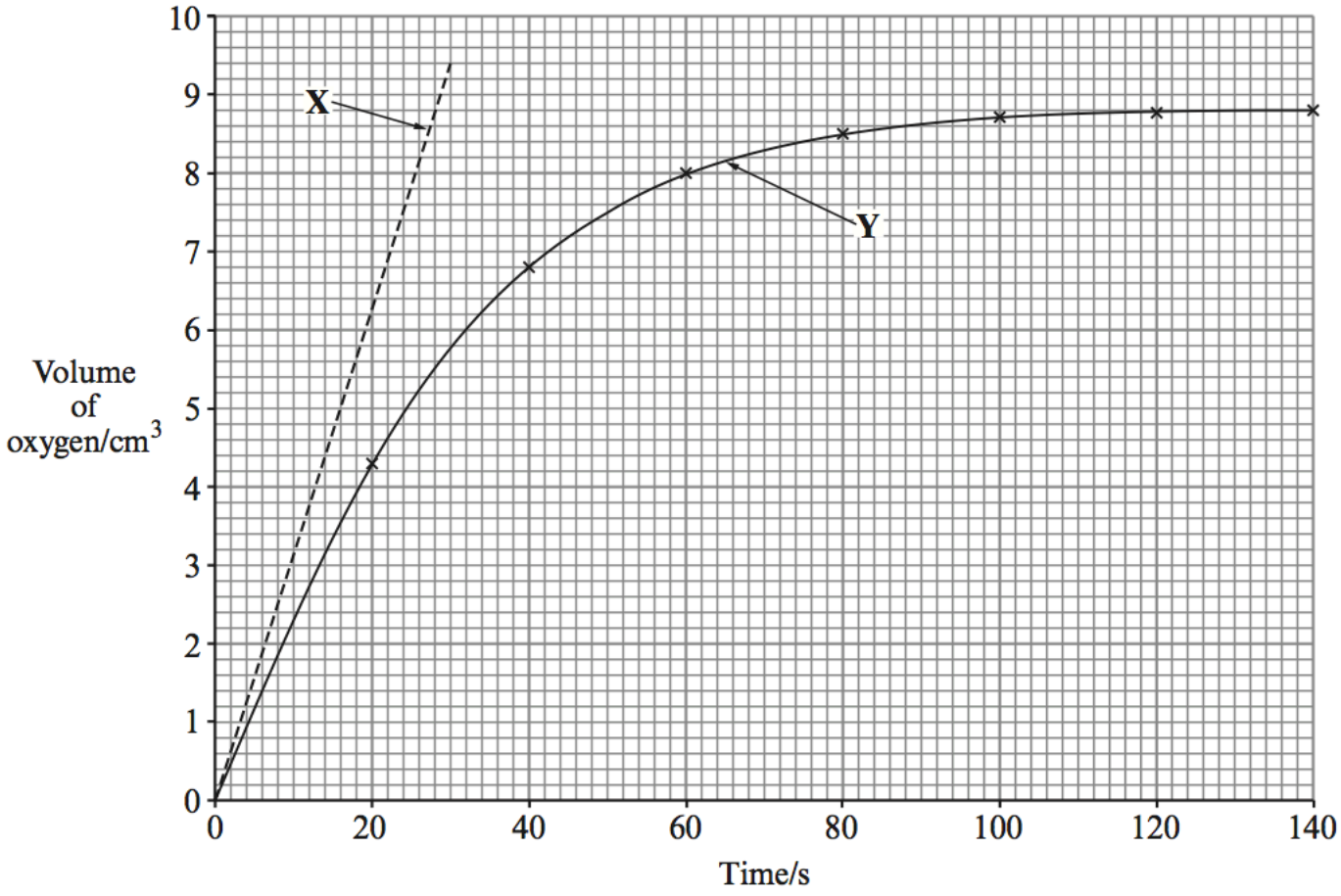
(Total 8 Marks)

9.

A student investigated the action of the enzyme catalase. This enzyme catalyses the breakdown of hydrogen peroxide into oxygen and water.
The student collected the oxygen given off in a measuring cylinder. The volume of gas was recorded every 20 seconds as shown on the graph labelled **Y** below.



(a) The rate of reaction can be calculated using the formula:

$$\frac{\text{Volume of oxygen collected}}{\text{Time taken to collect}}$$

Use the formula to calculate the rate in $cm^3 min^{-1}$ for the first 30 seconds. [2]

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(b) The initial rate is the rate of reaction at the beginning and is the maximum rate. It is shown by line **X**. The initial rate is 19 $cm^3 min^{-1}$.
Explain why the initial rate is greater than the rate calculated in *(a)*. [2]

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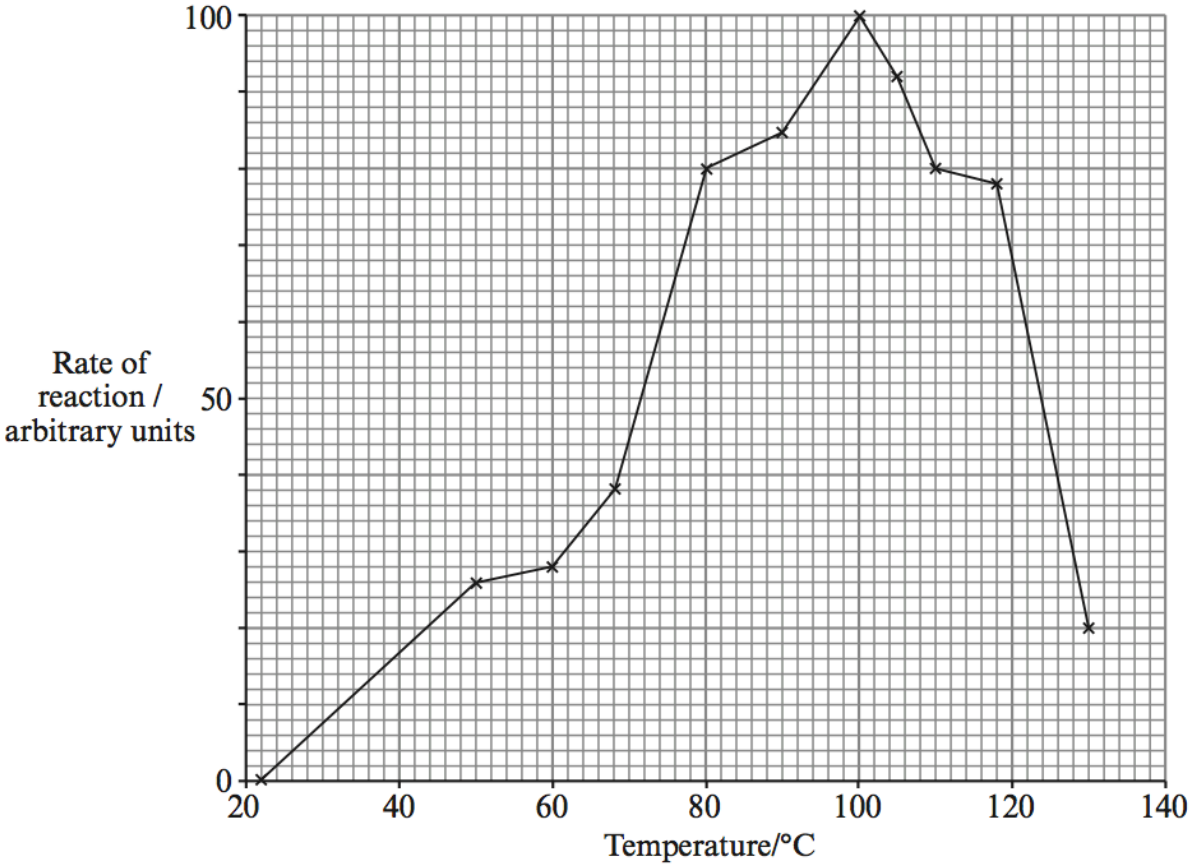
(c) The graph below shows the effect of temperature on the activity of an amylase enzyme found in bacteria that live in hot water in volcanic regions.



(i) Using the graph, describe and explain the effect of temperature on the rate of activity of the amylase. [6]

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(ii) State the difference between bacterial amylase and an amylase found in humans. [2]

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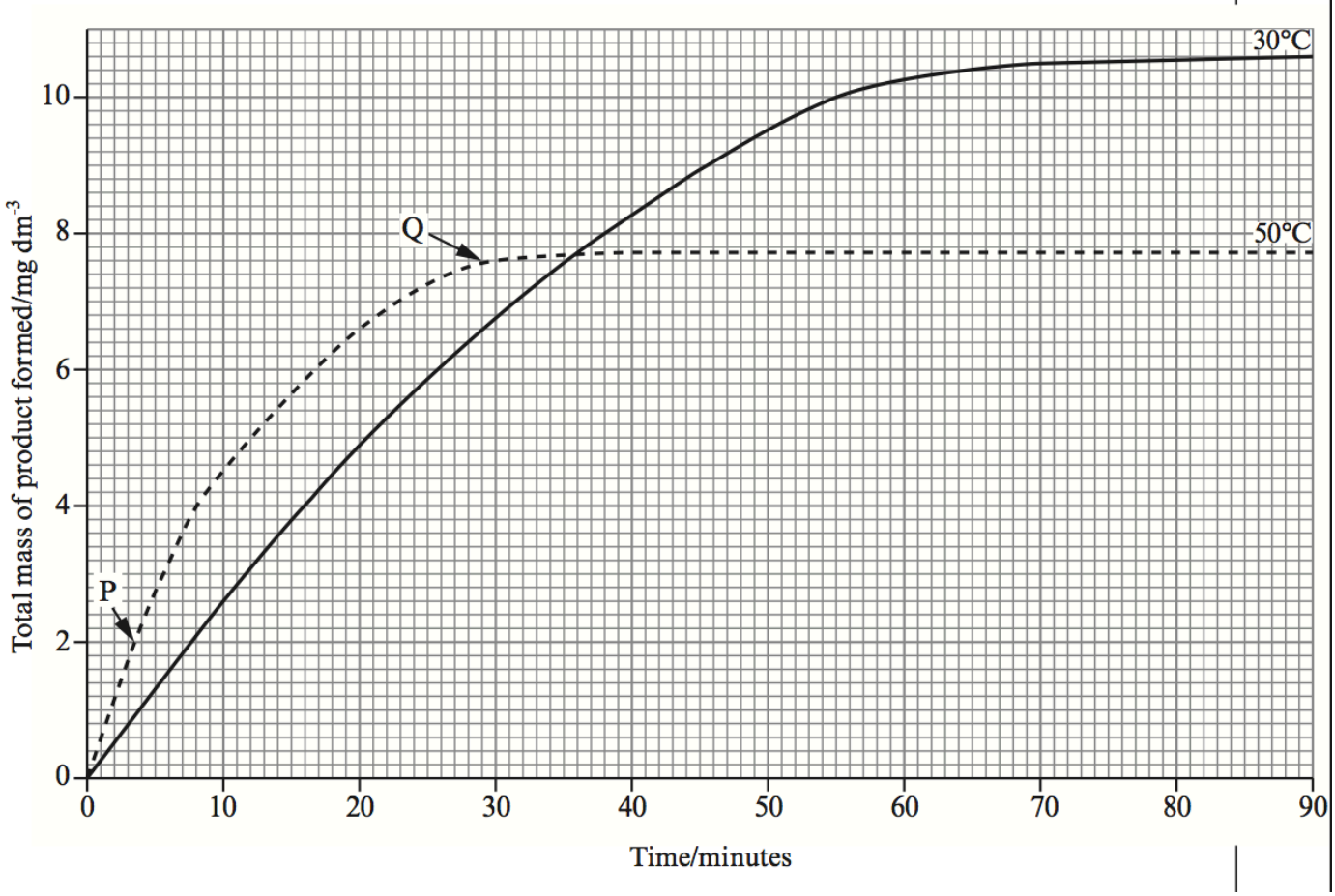
(Total 12 Marks)

10.

4. An investigation was carried out to determine the mass of product formed in an enzyme-controlled reaction at two different temperatures, with an excess concentration of substrate. The results are shown in the graph.



(a) (i) Calculate the rate of reaction in the first 10 minutes at 30°C. [1]

Rate = ... mg dm^{-3} min^{-1}

(ii) State the factor which determines the rate of reaction between points **P** and **Q** on the graph. [1]

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(b) (i) Explain why the initial rate of reaction was slower at 30°C than at 50°C. [2]

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(ii) Explain the shape of the curve between 30 minutes and 60 minutes at 50°C. [3]

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(c) The investigation was repeated at 30°C with the addition of a competitive inhibitor.

(i) Draw the expected curve on the graph. [1]

(ii) Explain how a competitive inhibitor would bring about this effect. [3]

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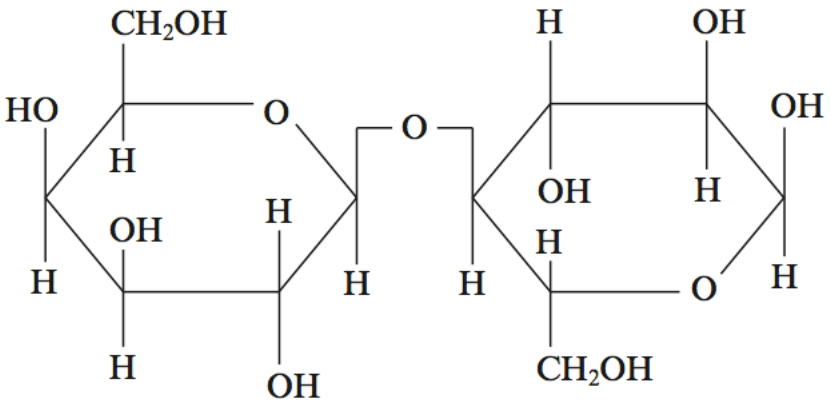
(Total 11 marks)

11.

Lactose is a disaccharide found in milk. The diagram below shows the structure of lactose.



(a) Lactose can be broken down into its constituent monosaccharides.

(i) Complete the diagram above to show how lactose is broken down. [2]

(ii) State the type of reaction involved in the breakdown of lactose. [1]

.....

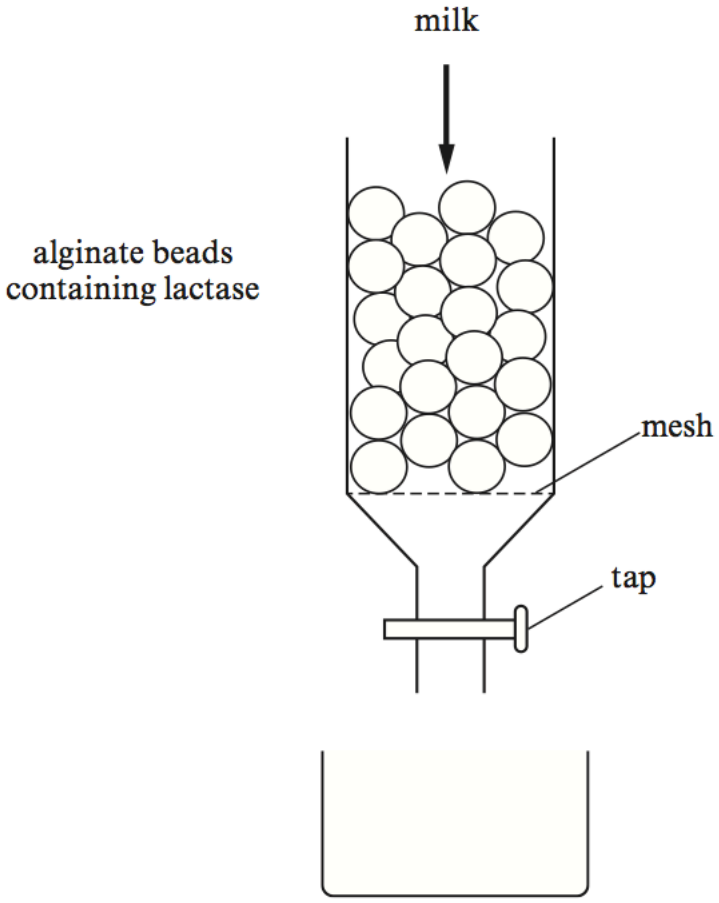
(iii) Name the bond that is broken during this reaction. [1]

.....

(iv) Name the molecules produced when lactose is broken down. [1]

.....

(b) The enzyme lactase can be used to break down lactose. In an experiment lactase was immobilised inside alginate beads and placed in a column, as shown in the diagram below. Fresh milk was then poured into the column and left for one minute before being allowed to drain into the beaker below. As the milk passes through the column the lactose in the milk is broken down.



(i) What is meant by the term immobilised enzyme? [1]

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(ii) Describe **two** advantages of using immobilised enzymes in this way. [2]

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(c) (i) The products produced from the breakdown of lactose are reducing sugars. Describe how you could test for the presence of a reducing sugar. [2]

(ii) The products produced could also be detected by a biosensor. What is meant by the term biosensor? [1]

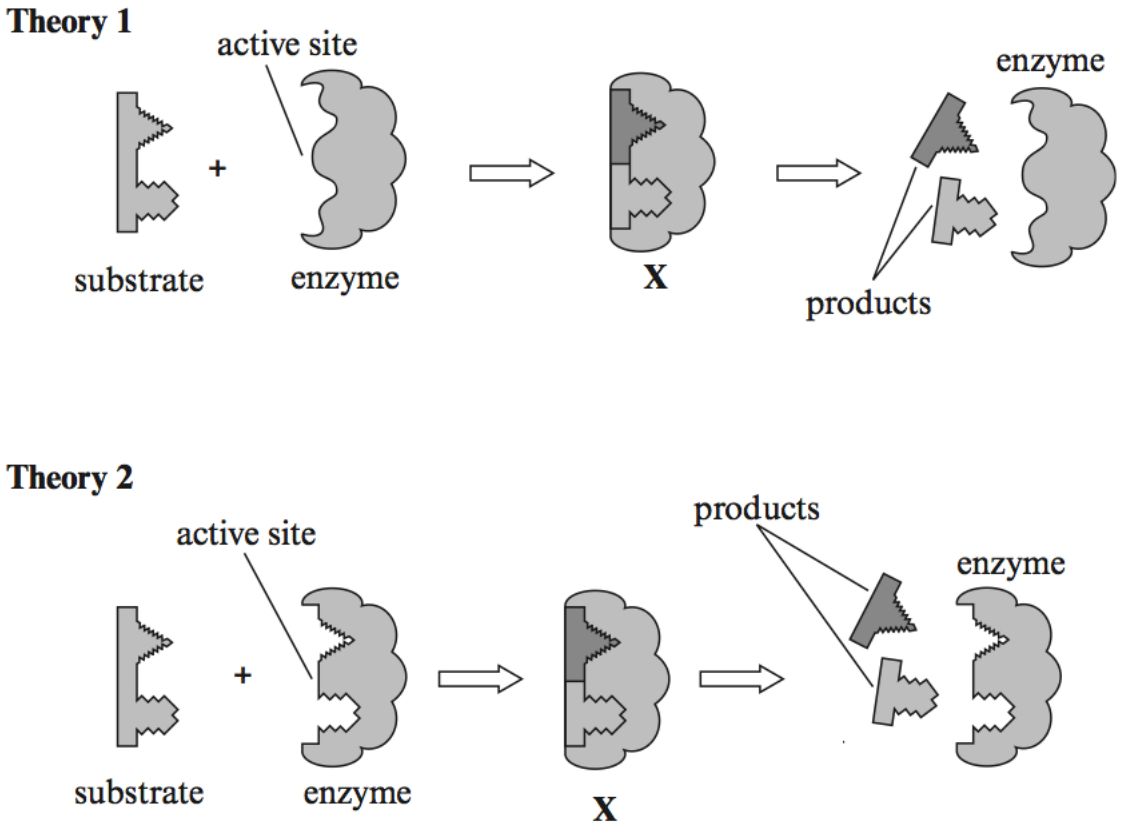
(iii) What would be the main advantage of using the biosensor to detect the products? [1]

(d) Some bacteria which are found in milk can convert sugars within the milk to lactic acid. Over time the number of these bacteria increase and this eventually causes milk to go sour. The experiment above was repeated with milk that had been left for seven days. State and explain the effect this would have on the concentration of reducing sugars detected. [4]

(Total 16 marks)

12.

The diagram below shows two theories used to explain enzyme activity.



(a) (i) **Theory 1** shows the induced fit hypothesis. What name is given to **Theory 2**? [1]

.....

(ii) Which theory represents the activity of lysozyme? [1]

.....

(b) Name **X** as shown in both theories. [1]

.....

(c) Enzymes are biological catalysts. How do they bring about their effect of speeding up a reaction? [1]

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.....

(d) What characteristic of an enzyme at the **end of a reaction** is visible in both diagrams? [1]

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(e) State **three** factors which affect enzyme activity, excluding the presence of inhibitors. [3]

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(f) Distinguish between intracellular and extracellular enzymes. [1]

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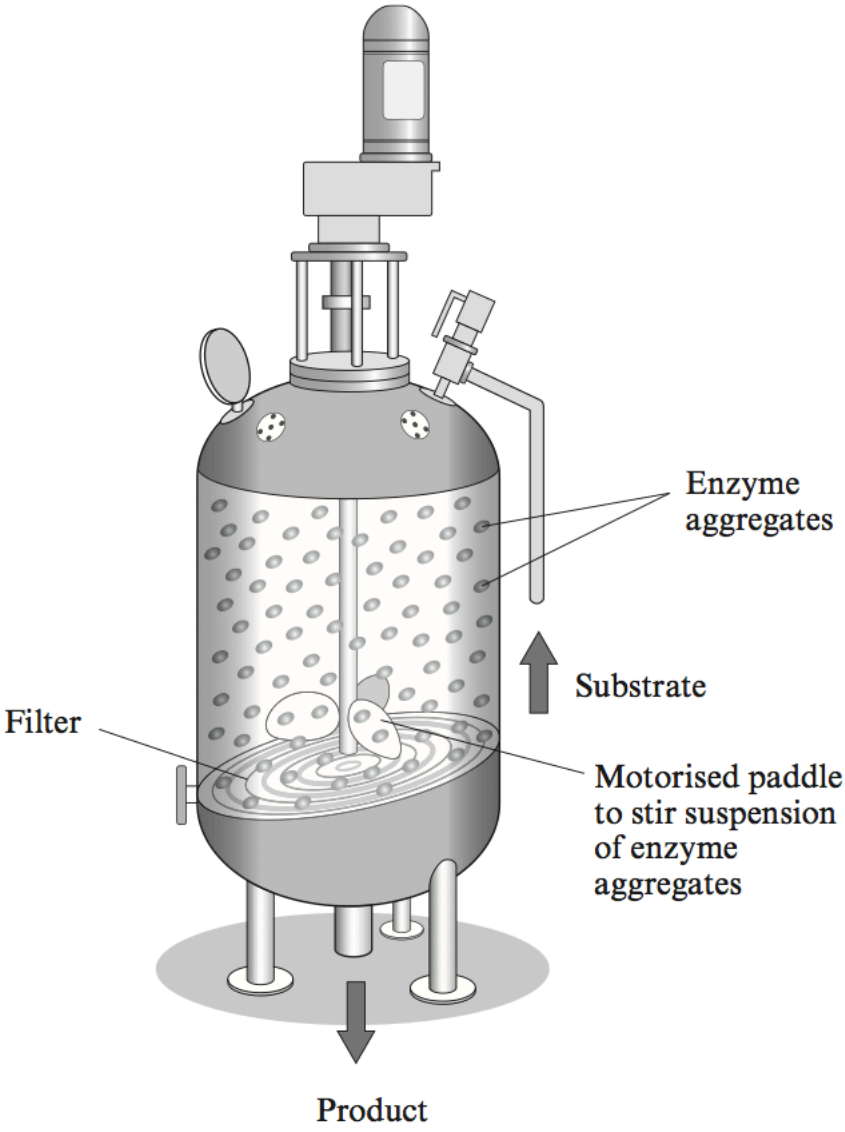
(Total 9 marks)

13.

Immobilised enzymes are prepared for industrial use in a number of ways. In the vessel shown below, the enzymes have been formed into clumps called enzyme aggregates. These are held together by cross-linking without altering their tertiary structure. They are permanently insoluble but maintain their catalytic activity.



(a) Why is it important that the tertiary structure of these enzymes is not altered by the cross-linking? [2]

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(b) Using your own knowledge and the diagram opposite, explain why it is necessary for these enzyme aggregates to be insoluble. [2]

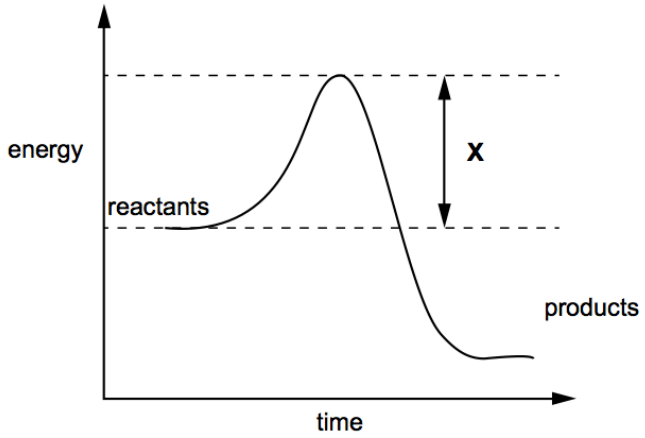
(c) State **three** advantages in using immobilised enzymes in industry. [3]

(d) Name another method of immobilising enzymes, other than cross-linking. [1]

(Total 8 marks)

14.

The graph below shows the energy changes that take place during a chemical reaction.

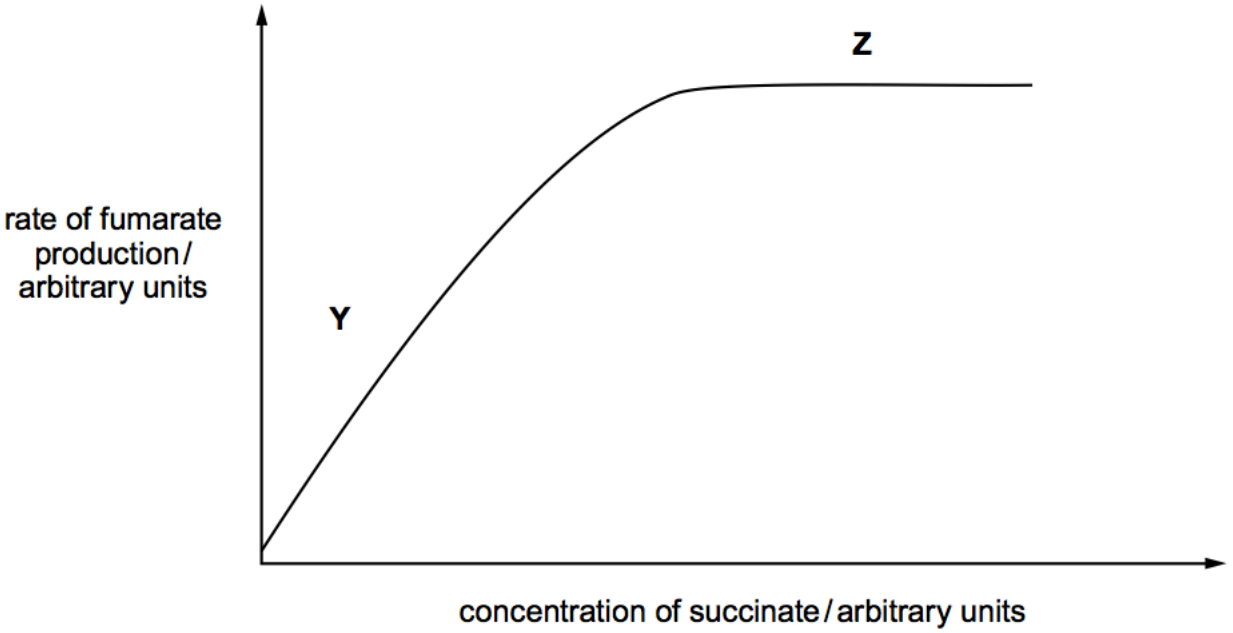


(a) (i) What is represented by **X** on the graph above? [1]

(ii) Enzymes are biological catalysts.
Draw a line on the graph above to show the energy changes that would take place if an enzyme was present during the reaction. [1]

(b) Succinate dehydrogenase is an enzyme found in mitochondria and is involved in respiration. The enzyme catalyses the conversion of succinate into fumarate. Using your knowledge of enzyme structure, explain why this is the **only** reaction succinate dehydrogenase can catalyse. [2]

(c) The graph below shows the rate of fumarate production at varying concentrations of succinate, at optimum temperature and pH with no inhibitors present.



(i) I State what factor is limiting the rate of reaction in the region marked **Y** on the graph. [1]

.....

II Use evidence from the graph to support your answer. [1]

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(ii) Explain what is limiting the rate of reaction in the region marked **Z** on the graph. [2]

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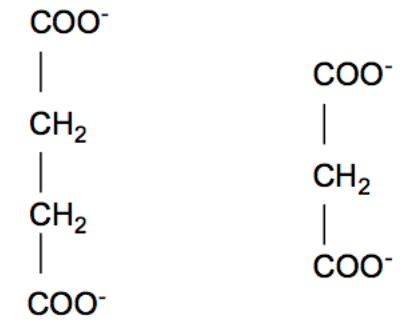
(d) Malonate is a competitive inhibitor of succinate dehydrogenase. The diagrams below show the structural formulae of succinate and malonate.



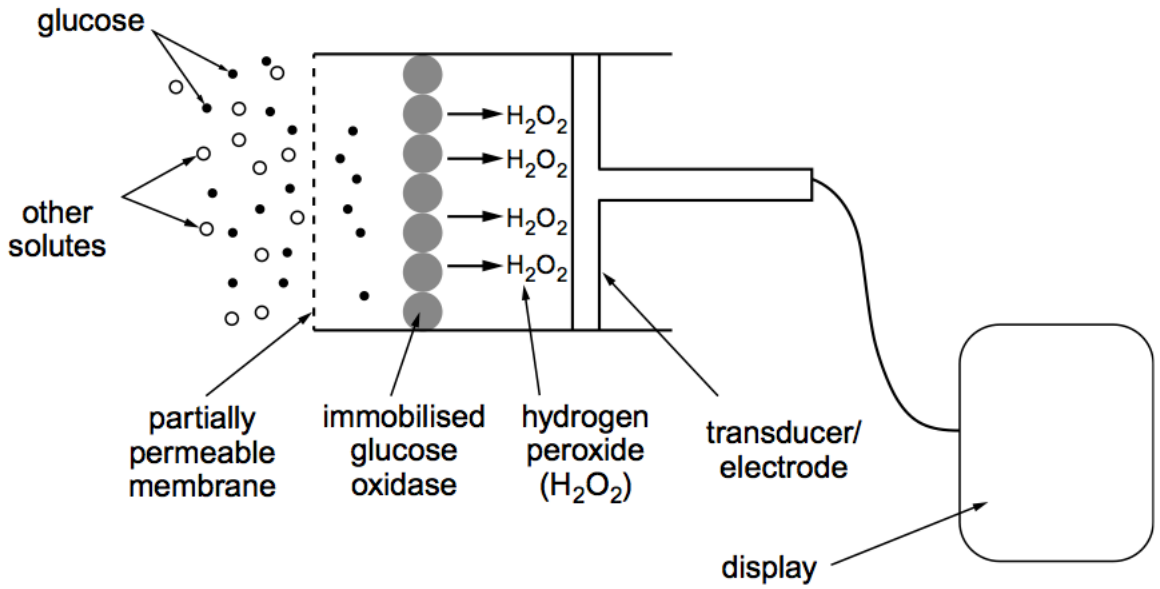
succinate malonate

(i) Using the information in the diagram above and your own knowledge, explain how malonate inhibits succinate dehydrogenase. [3]

(ii) On the graph in part *(c)* opposite draw a curve to show the rate of reaction when malonate is present. [1]

15.

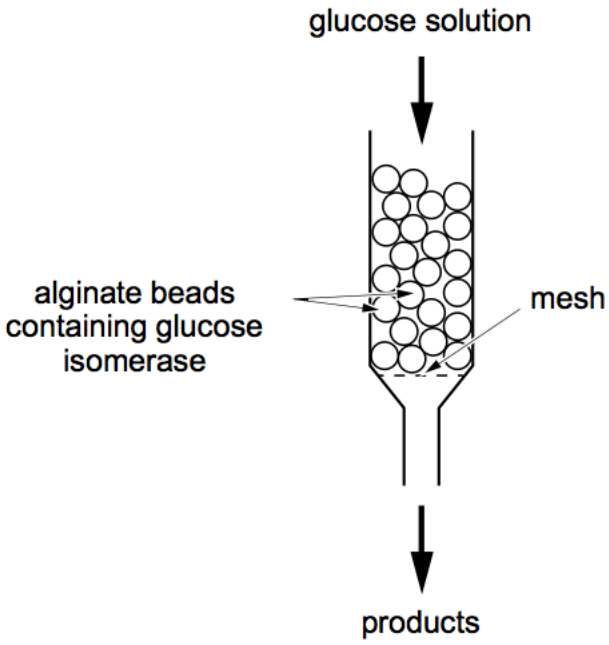
Biosensors make use of immobilised enzymes to detect specific molecules in a mixture. The diagram below shows a possible structure of a biosensor used to monitor blood glucose concentration.



(a) (i) Describe the function of the partially permeable membrane in this biosensor. [2]

(ii) With reference to the diagram above, describe how the concentration of glucose is transmitted to the display. [3]

Immobilised enzymes are also used in the food industry to produce many useful substances, for example fructose syrup. The diagram below shows a simplified version of this process. A glucose solution is passed through a column of the immobilised enzyme glucose isomerase and fructose is released as a product.



(b) (i) Suggest why the enzyme involved is called glucose isomerase. [1]

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(ii) One of the advantages of using immobilised enzymes is that the product does not contain the enzyme and therefore does not need to be purified.
Describe a biochemical test that could be used to show that the product has not been contaminated by the **enzyme**. [2]

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(iii) Describe **two** *other* advantages of using immobilised enzymes. [2]

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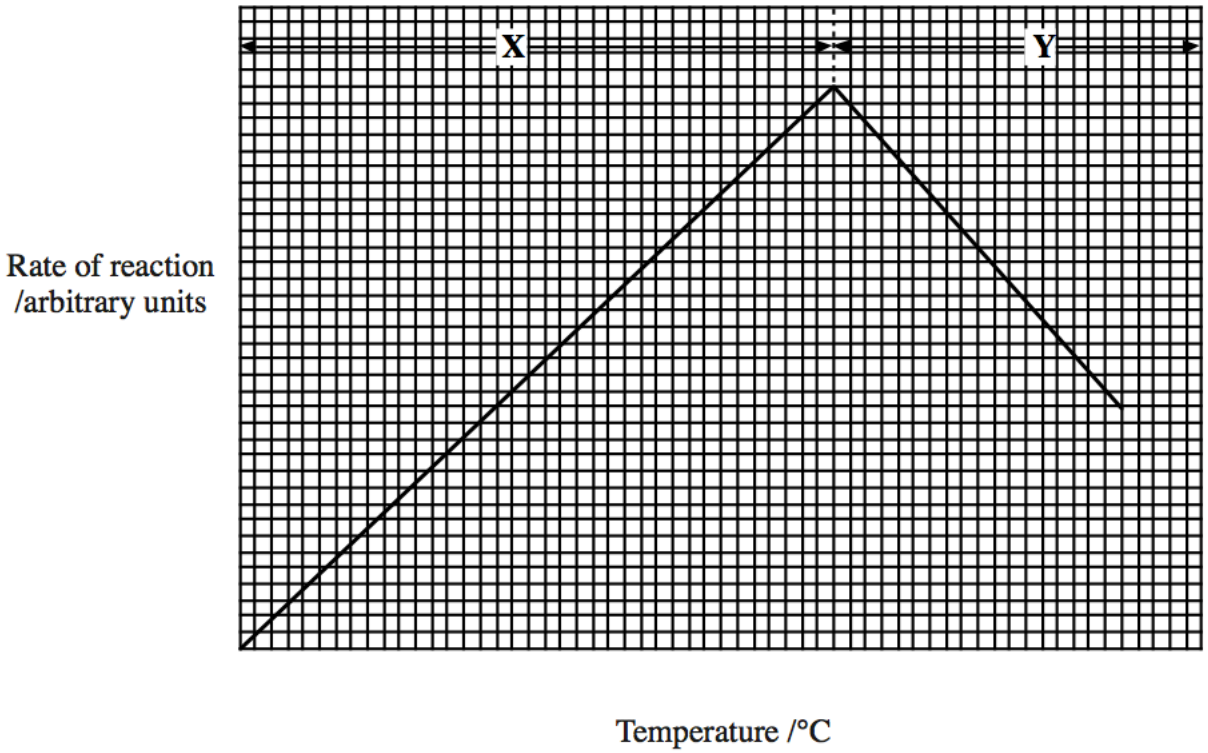
16.

The graph below shows the results from a number of experiments to determine the effect of temperature on the rate of a reaction catalysed by a mammalian enzyme.



(a) Add the scale and numbers on the temperature axis for a typical mammalian enzyme. [3]

(b) (i) Explain the shape of the curve in region **X**. [2]

.....

.....

(ii) Explain the shape of the curve in region **Y**. [3]

.....

.....

.....

(c) If you were carrying out this experiment state **two** factors which you would need to keep constant in order to obtain reliable results. [2]

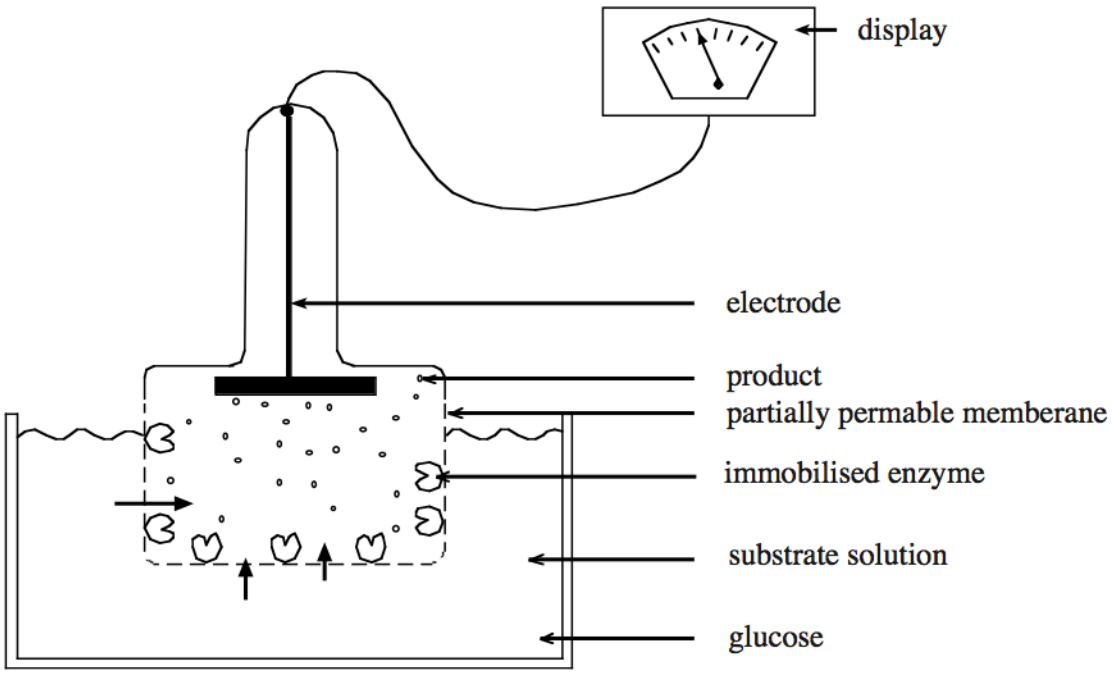
.....

.....

(Total 10 marks)

17.

The diagram below shows a possible structure for a biosensor that uses immobilised enzymes to detect glucose.



(a) What are immobilised enzymes? [1]

.....

.....

(b) Suggest what happens when the glucose in the solution reaches the immobilised enzymes. [2]

.....

.....

.....

(c) Suggest the form in which the information about the concentration of glucose is transmitted to the display? [1]

.....

.....

(d) (i) Why should a buffer be added to the substrate solution? [1]

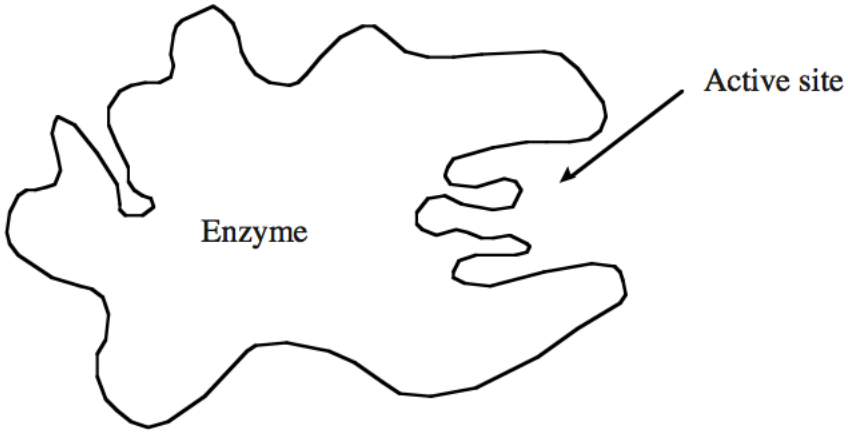
.....

.....

(ii) Suggest **one** other variable that should be kept constant. [1]

.....

(e) Competitive (X) and non-competitive (Y) inhibitors can be used to slow down or to stop enzyme controlled reactions. Label the diagram below to suggest where these inhibitors are most likely to act. Use X for the competitive inhibitor and Y for the non-competitive inhibitor. [2]



(f) Describe how each of these inhibitors work. [2]

X .....

.....

.....

Y .....

.....

.....

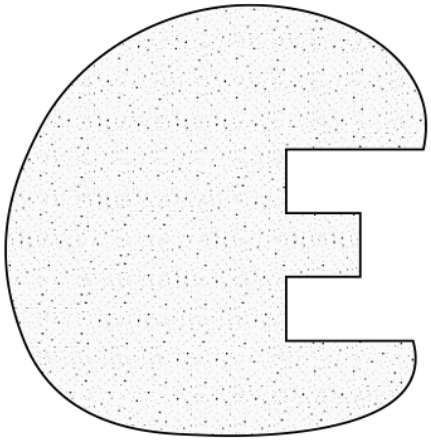
(g) Give an example of a competitive inhibitor. [1]

.....

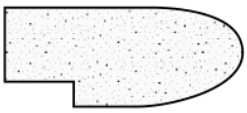
(Total 11 marks)

18.

The diagram shows an enzyme molecule and a molecule **X** that inhibits the enzyme.



enzyme



molecule **X**

(a) (i) What type of inhibition would molecule **X** cause? [1]

.....

(ii) Explain how molecule **X** would inhibit the enzyme. [2]

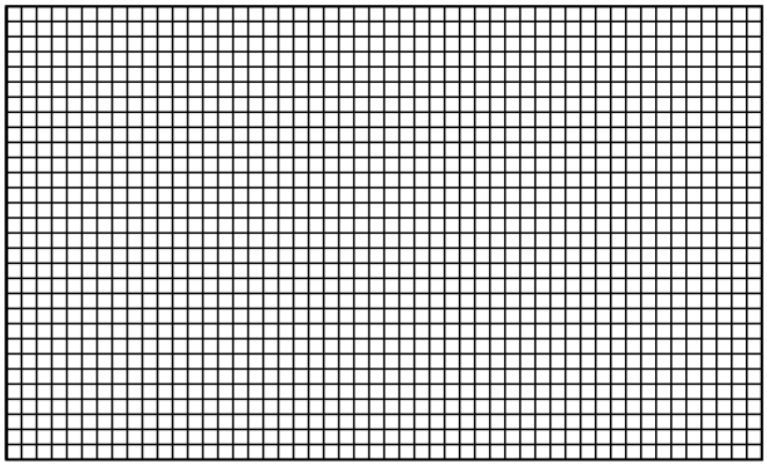
.....

.....

.....

(b) (i) This enzyme, which works very slowly below 5°C, has an optimum rate of working at 40°C and is completely denatured at 50°C.

On the grid below draw the curve that relates rate of activity of the enzyme to temperature. [4]



(ii) Explain why the enzyme works very slowly below 5°C. [1]

.....

.....

(iii) What may happen to the structure of the enzyme molecule when it is "completely denatured at 50°C"? [1]

.....

.....

19.

8. Fructose can be made from glucose using the enzyme isomerase. This enzyme can be immobilised. The glucose is allowed to flow over the immobilised enzyme and the fluid that flows out of the reaction vessel contains a high concentration of fructose.

(a) (i) What is meant by the term *immobilised* enzyme. [1]

.....

.....

(ii) Suggest **two** advantages of using immobilised enzyme in this industrial process. [2]

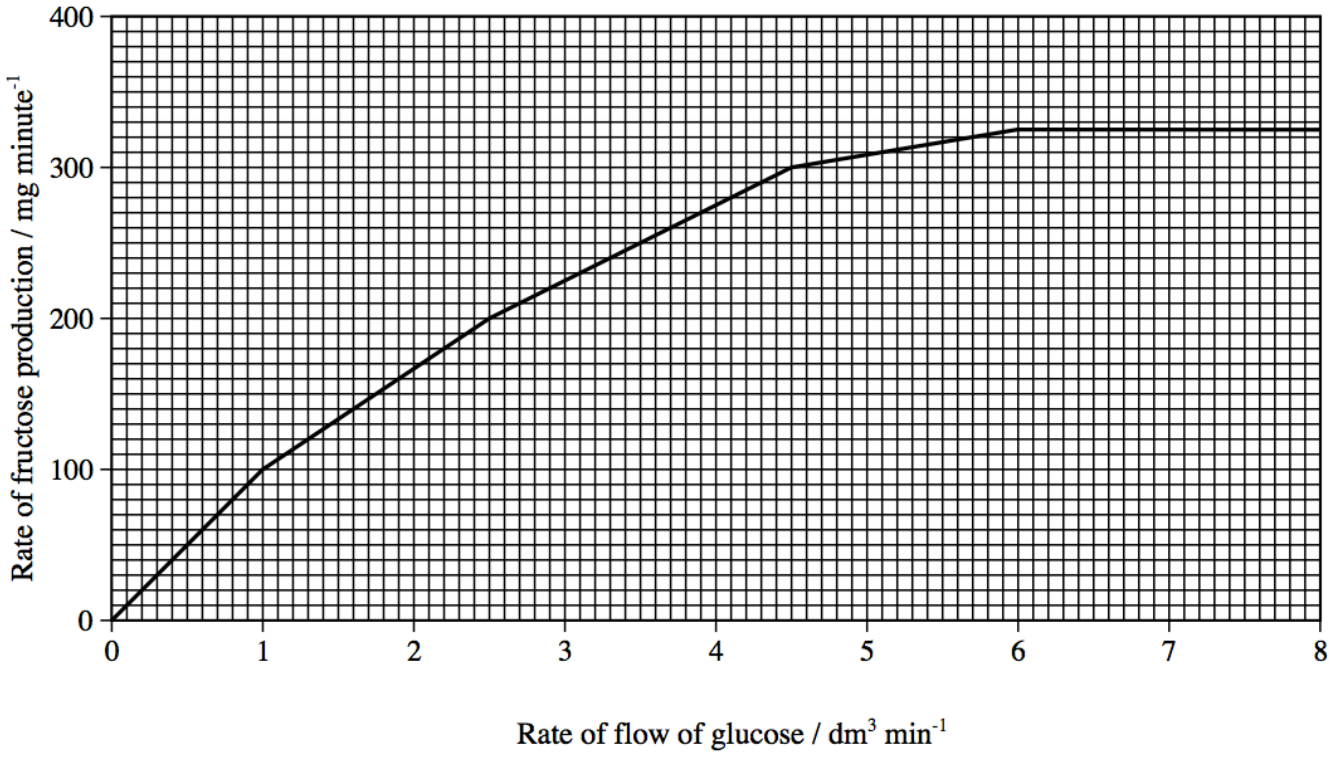
.....

.....

.....

.....

(b) The graph shows the effect of changing the rate of flow of the glucose solution on the rate of production of fructose.



(i) When the rate of flow was increased from 2.5 to 4.5 dm^3 per minute calculate the increase in fructose production per hour. Show your working. [3]

Answer .....

(ii) Explain what is happening at flow rates above 6 dm^3 per minute. [2]

.....

.....

.....

20.

Enzymes are often described as biological catalysts.

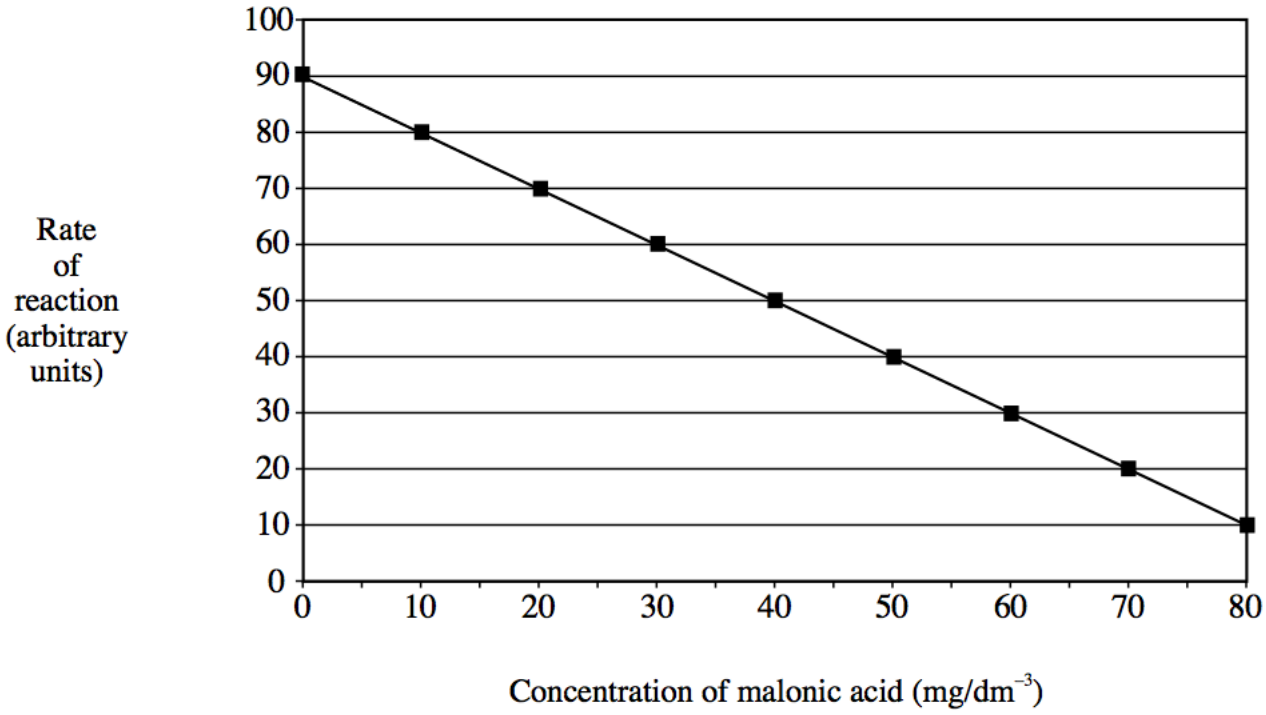
(a) What is a catalyst? [1]

.....

(b) What property of chemical reactions is lowered by enzymes, enabling them to proceed rapidly? [1]

.....

Malonic acid is known to be an inhibitor of the enzyme *succinic acid dehydrogenase*. A group of students carried out an experiment in which they mixed malonic and succinic acids with an extract prepared from living cells.
Their results are shown in the following graph.



(c) Describe the effect that increasing the concentration of malonic acid had on the rate of the reaction. [1]

.....

.....

(d) Name the type of inhibition that these results demonstrate. [1]

.....

(e) Using the 'lock and key' hypothesis, explain the effect you described in part (c). [3]

.....

.....

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(f) How could the students have ensured that the pH of their reaction mixtures did not change during the course of their experiment? [1]

.....

(g) Describe a suitable control that the students might have set up to show that an **enzyme** in the cell extract was being affected by malonic acid. [2]

.....

.....

.....

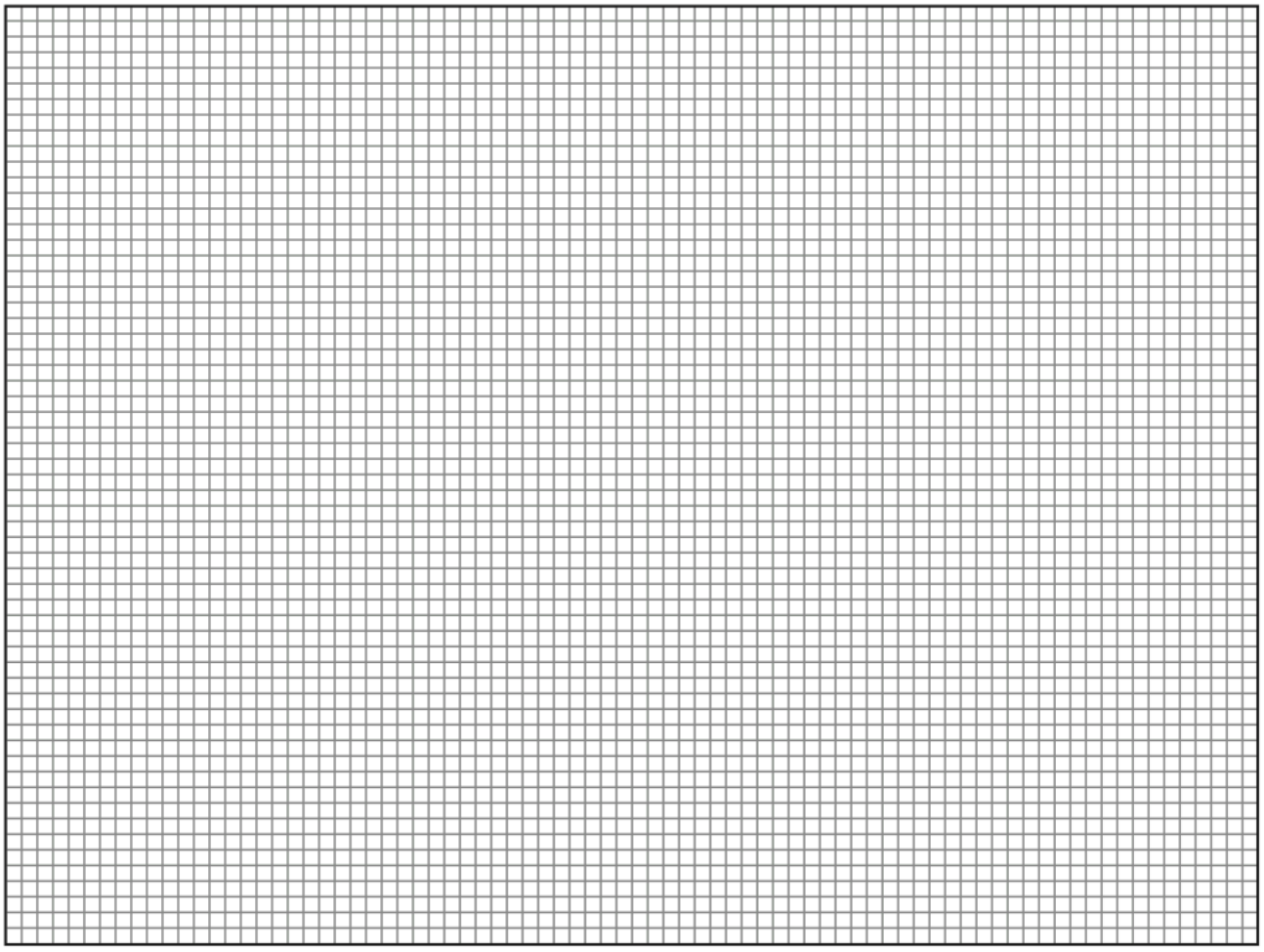
(Total 10 marks)

21.

The table below shows the results obtained when the activity of the enzyme salivary amylase was studied at a range of pH. The rate of reaction of the enzyme has been recorded as a proportion of its maximum activity.

	Rate of reaction (proportion maximum activity)								
	pH1	*pH3*	*pH4*	*pH5*	*pH7*	*pH8*	*pH9*	*pH11*	*pH13*
Salivary amylase	0%	0%	2%	12%	100%	40%	8%	1%	0%

(a) Construct a graph of this data on the grid provided.
Join the plots with a smooth curve. [5]



(b) (i) The stomach contents are at pH 2. Use your graph to determine the activity of salivary amylase in the stomach. [1]

.....

(ii) On your graph draw a curve to indicate the probable pattern of activity of the stomach enzyme pepsin. [2]

(c) Explain how a change in pH can affect the activity of an enzyme. [3]

.....

.....

.....

.....

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.....

(d) During the investigation described above, state **two** factors which must have been kept constant. [2]

1 .....

2 .....

(e) What would have been used to control the pH of the enzyme solutions? [1]

.....

(Total 14 marks)

22.

An investigation was carried out to monitor the course of an enzyme catalysed reaction in which the hydrolysis of a lipid (fat) occurred. A pH meter was used to follow the progress of the reaction.

(a) (i) State which type of enzyme would have been used. [1]

.....

(ii) Explain what is meant by the term *hydrolysis*. [2]

.....

.....

(iii) What changes to pH would have been recorded by the pH meter during the reaction? [1]

.....

Explain why these changes occurred. [1]

.....

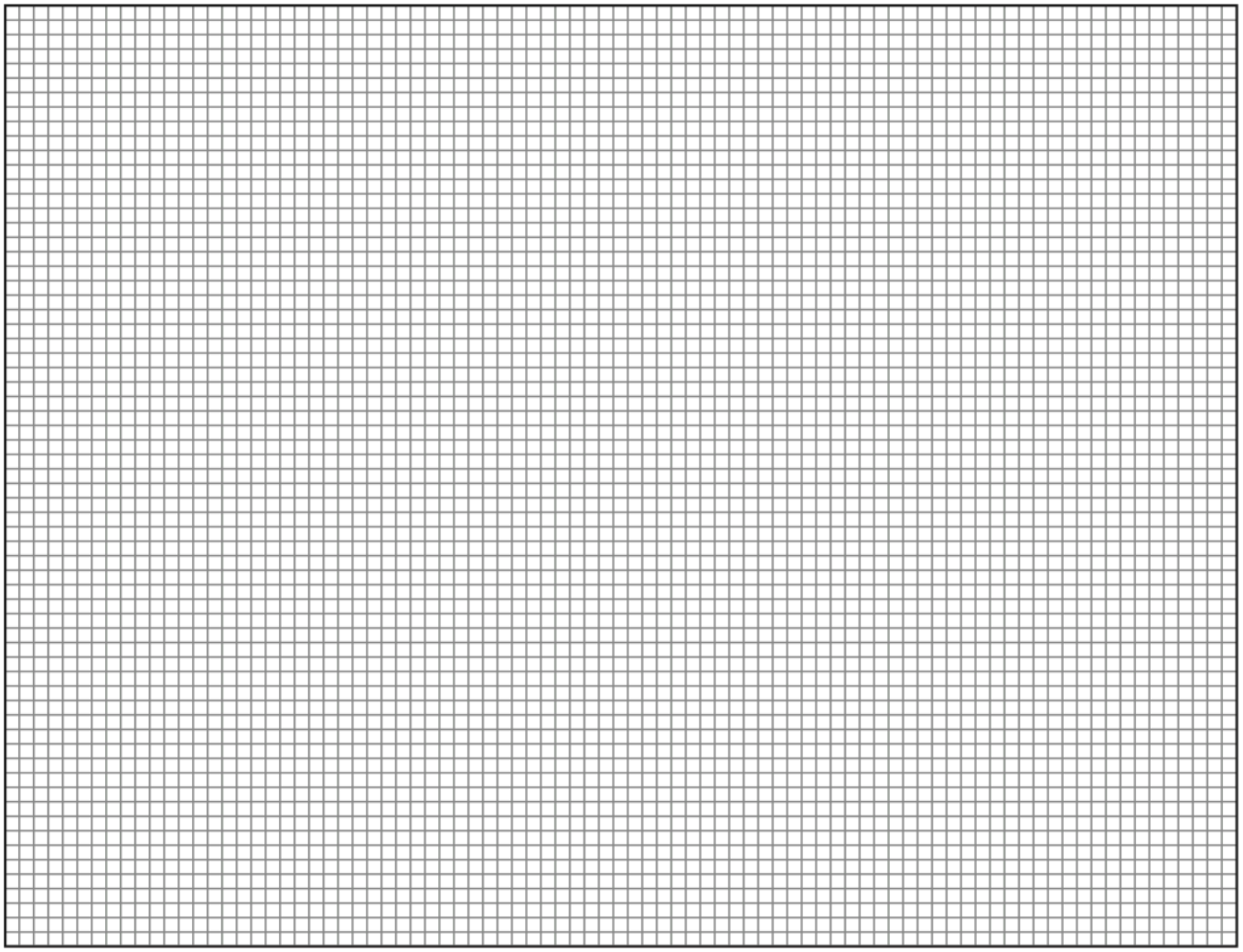
.....

.....

(b) This investigation was repeated several times using the same concentration of enzyme, but a different concentration of the lipid each time. The time taken for the pH meter to record no further change in pH was recorded and the rate of reaction at each lipid concentration was calculated. The results of each experiment are set out in the table below.

Lipid concentration/%	*Rate of reaction/ arbitrary units*
0.1	0.6
0.2	1.3
0.3	1.9
0.4	3.0
0.5	4.0
0.6	4.8
0.7	5.8
0.8	5.8

(i) Plot the results of the investigation on the graph paper below. [3]



(ii) What happens to the rate of reaction when the lipid concentration rises from 0.7% to 0.8%? Explain your answer. [2]

.....

.....

.....

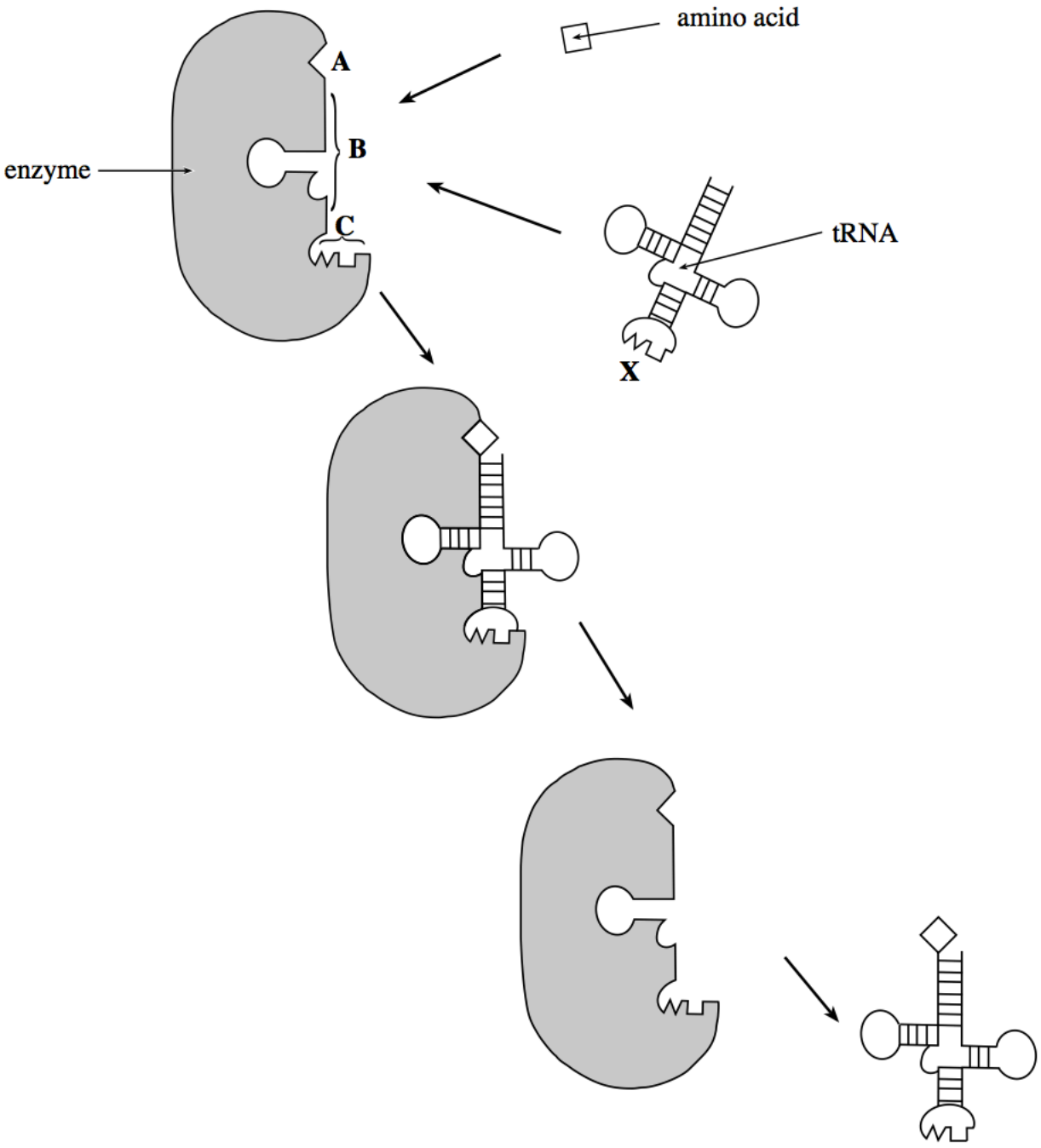
.....

(iii) The investigation was performed at 25°C. Draw a second line on the graph to show the expected results if the experiment had been carried out at 35°C. Label your line 35°C. [1]

(Total 11 Marks)

23.

During protein synthesis, amino acids are carried by tRNA. Each amino acid is first joined to its tRNA by an enzyme. The diagram below shows the stages in this process.



(a) What is the name given to the region consisting of **ABC**? [1]

.....

(b) State the theory which describes how an enzyme combines with a specific substrate. [1]

.....

(c) The shape of the enzyme molecule partly depends upon different types of bond. Name **two** of these bonds. [2]

.....

.....

Each amino acid will combine with only one enzyme.

(d) Using a letter from the diagram state which region of the enzyme is responsible for this specificity. [1]

.....

(e) Apart from the enzyme, one other molecule is needed to activate the joining of the amino acid and tRNA. Name this molecule, which is not shown in the diagram. [1]

.....

(f) (i) Name the region labelled **X** in the diagram. [1]

.....

(ii) Explain the importance of region **X** in protein synthesis. [1]

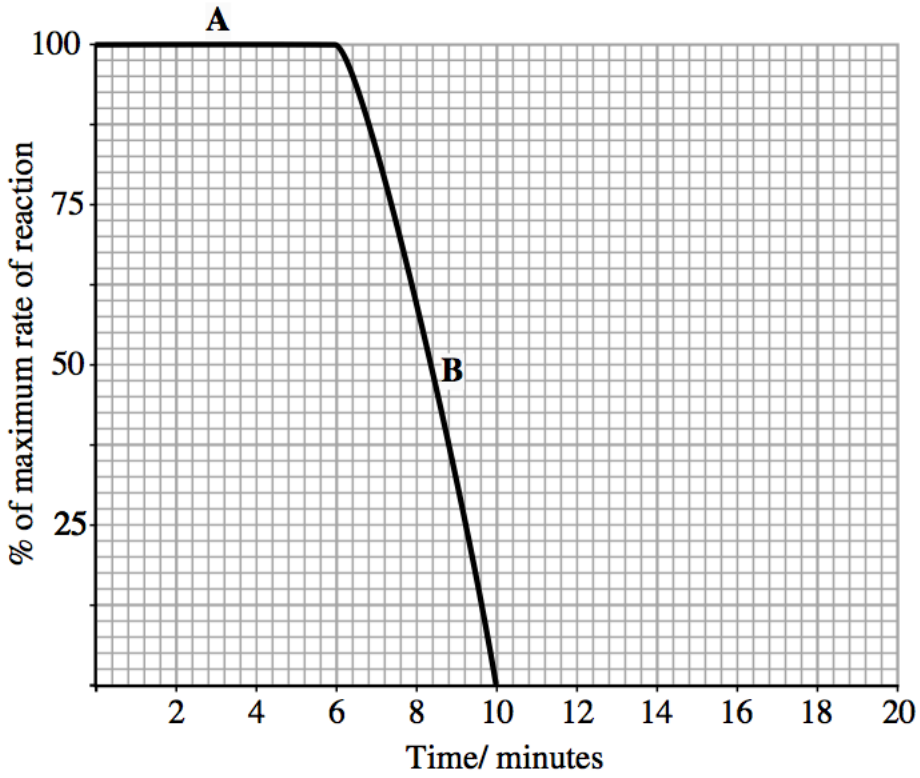
.....

.....

(Total 8 marks)

24.

An enzyme extract was added to a known concentration of substrate and the rate of reaction monitored every two minutes over a twenty-minute period. The results are shown on the graph below.



(a) State **two** factors that need to be controlled in order to obtain reliable results. [2]

.....

.....

(b) (i) Explain why the region labelled **A** on the graph is horizontal. [1]

.....

.....

(ii) Explain the shape of region **B**. [1]

.....

.....

(c) The experiment was repeated but the enzyme extract was diluted to half its original strength. Draw accurately on the above graph the results you would expect to see. [3]

(d) (i) Explain what is meant by the term immobilised enzyme. [1]

.....

.....

(ii) Give **two** advantages of using immobilised enzymes in industry. [2]

.....

.....

.....

.....

(iii) Give **one** use of immobilised enzymes in industry or medicine. [1]

.....

(Total 11 marks)

25.

(a) Define the following terms as used to describe enzyme inhibition. [6]

Competitive inhibitor

.....

.....

.....

.....

Non competitive inhibitor

.....

.....

.....

.....

End product inhibition

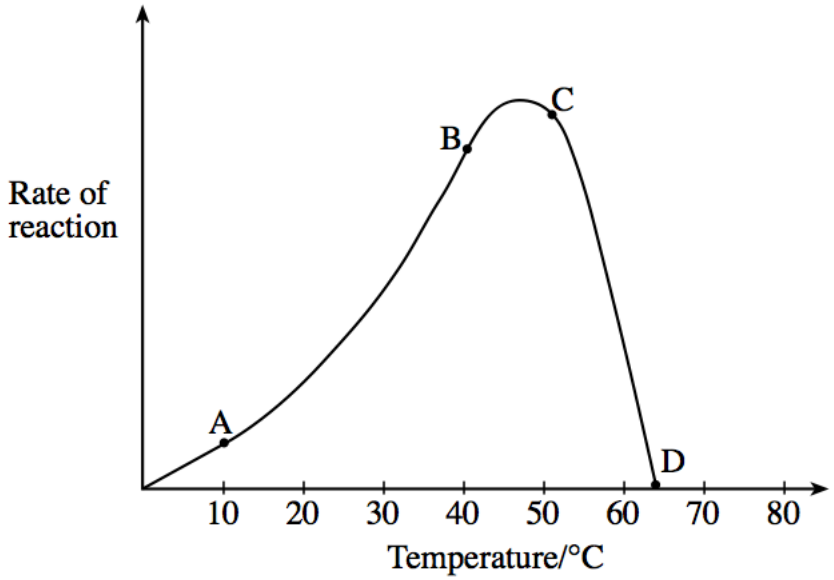
.....

.....

.....

.....

(b) The graph represents the effect of an increase in temperature on the rate of enzyme activity.



Give an explanation for the shape of the curve between A and B and C and D. [4]

A and B .....

.....

.....

.....

C and D .....

.....

.....

.....

(c) Suggest why the temperature of a mammal is maintained just below the optimum temperature for the enzymes in that mammal. [2]

.....

.....

.....

.....

(Total 12 marks)

26.

Milk can be made lactose-free by passing it down a column of the immobilised enzyme lactase. An experiment was carried out to determine the optimum size of alginate beads to use in this process.
Three bead sizes were prepared and placed in columns. The same volume of milk was run into each column at the same rate of flow.
The percentage product for each experiment was determined.
The entire experiment was repeated a number of times.

	Bead diameter (mm)		
	2	*4*	*6*
Mean percentage of product	98	84	70

(a) (i) Suggest the bead size which should be used in the process. Give a reason for your answer. [1]

.....

.....

(ii) Give **two** reasons for the different results from the three bead sizes. [2]

.....

.....

.....

(iii) What would you expect to happen to the results if the flow rate was decreased? Explain your answer. [1]

.....

.....

(iv) Which **other** factor should be kept constant during the experiment? [1]

.....

(b) Name the **two** monosaccharides produced by the breakdown of lactose. [1]

.....

(c) Give **two** advantages of using immobilised enzymes in industrial processes. [2]

1 .....

2 .....

(Total 8 marks)

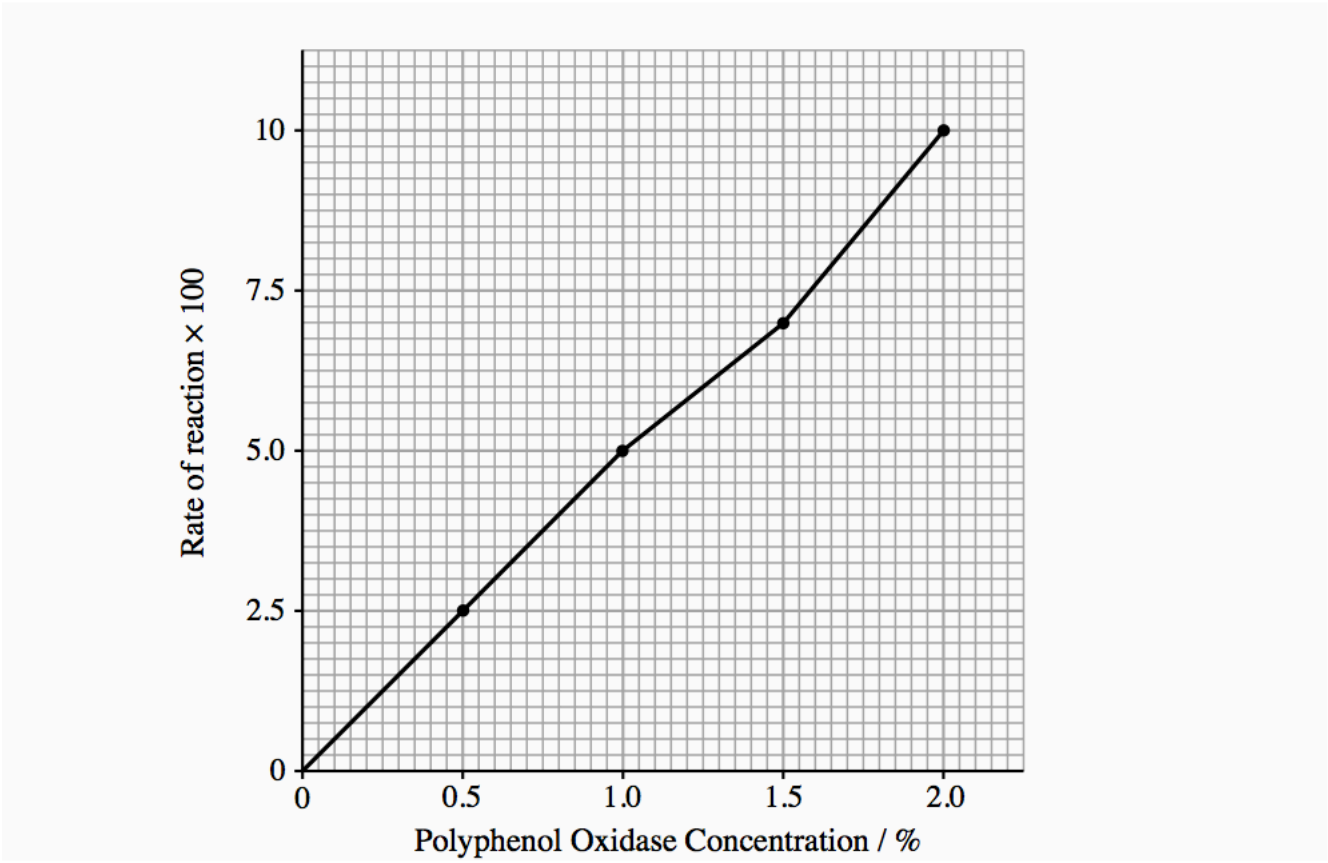
27.

When a potato tuber is cut open, the surfaces exposed to the air gradually turn brown due to the production of dark brown coloured pigments from phenolic compounds (e.g. catechol). The enzyme, polyphenol oxidase, catalyses this process.

The graph below shows the results of an experiment in which different concentrations of the enzyme were added to tubes containing catechol solution. The tubes were kept at a constant temperature and shaken periodically during the experiment.

The time taken for a standard brown colour to develop was recorded and from this the rate of reaction was calculated, using $\frac{1}{\text{time in minutes}}$ for the colour to develop.

A graph was then plotted of rate against enzyme concentration.



(a) What general conclusion concerning enzyme action can be drawn from these results? [1]

.....

.....

(b) At what enzyme concentration would the standard colour be obtained after 18 minutes? Show your working. [2]

.....

.....

(c) How would you set up a control tube? [1]

.....

.....

(d) Explain why the addition of lemon juice (citric acid) to the tubes stops any colour change. [1]

.....

.....

(e) Explain what is likely to happen to the rate of colour change if the temperature of a tube containing the enzyme polyphenol oxidase and catechol was gradually raised from 10°C to 100°C. [2]

.....

.....

.....

.....

(f) Suggest what might happen to the rate of reaction if a competitive inhibitor were added. Explain your answer. [2]

.....

.....

.....

.....

(g) 'All enzymes are proteins,' describe how you would test to show that polyphenol oxidase is a protein. [2]

.....

.....

.....

.....

(Total 11 marks)

28.

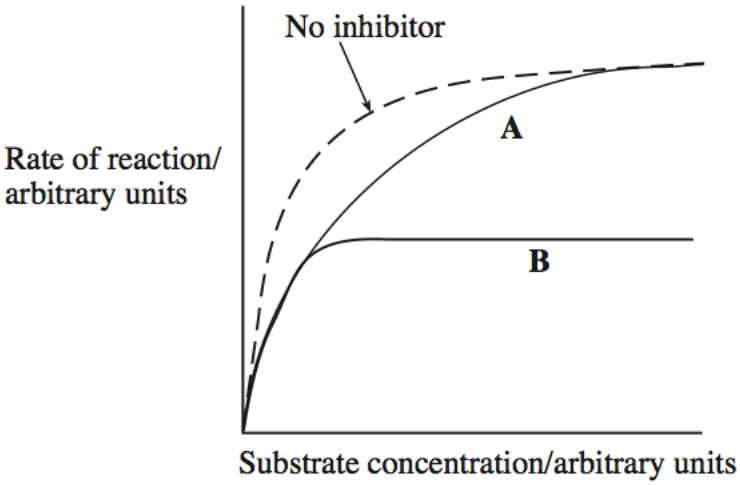
(a) Apart from the presence of inhibitors and substrate concentration, state **three** factors that affect the rate of an enzyme controlled reaction. [3]

.....

.....

.....

(b) The graph shows how the rate of an enzyme catalysed reaction varies with substrate concentration when affected by a competitive inhibitor and a non-competitive inhibitor.



(i) Which line shows the competitive inhibitor? [1]

.....

(ii) Give a reason for your choice in *(b)*(i). [1]

.....

.....

(iii) Explain how a competitive inhibitor works. [3]

.....

.....

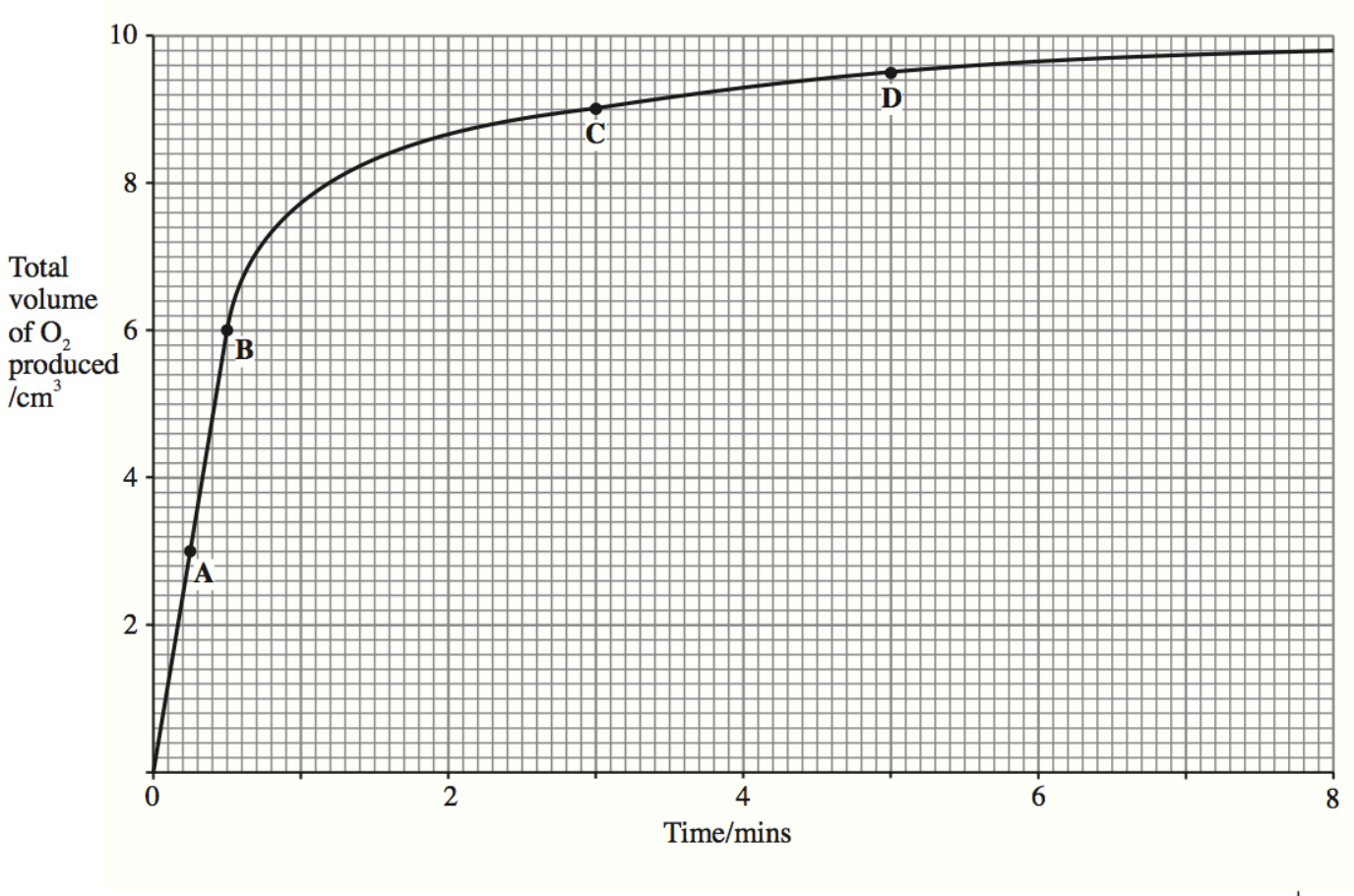
.....

.....

(Total 8 marks)

29.

2. The enzyme catalase is found in raw potato. It breaks down hydrogen peroxide, releasing oxygen. Minced potato was placed in a buffer solution in a flask. 5cm^3 of 3% hydrogen peroxide solution was run into the flask and the oxygen given off was collected in a graduated flask. The volume of oxygen present was noted every 30 seconds and the results are shown in the graph.



(a) (i) Calculate the mean value of the reaction rate (in cm^3 O_2 min^{-1}) for the period from **A** to **B**. [1]

.....

(ii) How much greater is this value than that for **C** to **D**? [1]

.....

(b) What is the limiting factor on the rate of reaction

(i) between **A** and **B**, [1]

.....

(ii) between **C** and **D**? [1]

.....

(c) (i) Draw a line on the graph to show the effect of adding a small quantity of a non-competitive inhibitor at the start of a similar experiment. [1]

(ii) Explain the position you have chosen for your line. [1]

.....

.....

(iii) Explain why the inhibitor is referred to as non-competitive. [2]

.....

.....

(d) Suggest why the potato was minced. [1]

.....

(e) Explain why the absence of a buffer solution would make it difficult to obtain reproducible results. [2]

.....

.....

(f) The flask was clamped in a constant temperature water bath. Explain why. [1]

.....

.....

(g) Suggest what might happen to the enzyme if the temperature was allowed to rise above 60°C. [1]

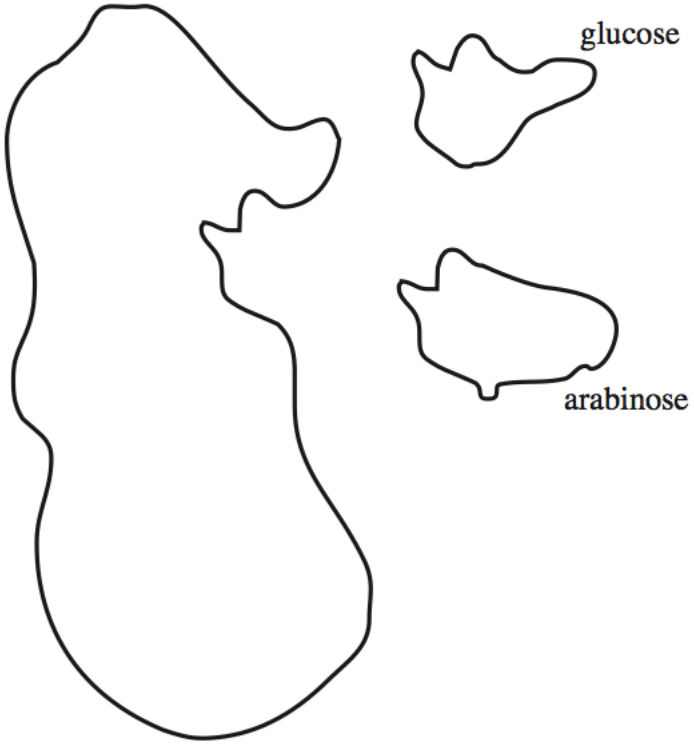
.....

(Total 13 marks)

30.

Glucose oxidase is an enzyme, shown below, the normal substrate of which is glucose.

The molecule arabinose acts as an inhibitor for the glucose oxidase.



(a) (i) Name the class of molecule to which enzymes belong. [1]

.....

(ii) On the diagram, label the position of the enzyme's active site. [1]

(iii) Explain why you chose that position. [2]

.....

.....

.....

(b) Explain how arabinose inhibits the activity of glucose oxidase. [4]

.....

.....

.....

.....

.....

.....

(c) If a person drinks methylated spirits (meths), blindness can result because the body turns the meths into formaldehyde, which is highly poisonous. One form of hospital treatment is for the patient to drink alcohol (ethanol) which is a molecule of a similar structure to meths.

Suggest how this treatment will reduce the toxic effects of the meths. [3]

.....

.....

.....

.....

(Total 11 marks)

31.

Explain the meaning of the following.

(a) Active transport [1]

.....

.....

(b) The primary structure of a protein [1]

.....

.....

(c) Enzyme-substrate complex [1]

.....

.....

(d) Immobilised enzyme [1]

.....

.....

(Total 4 marks)

32.

An enzyme experiment was carried out using tubes which were labelled A to H.

An equal volume of an enzyme was added to each tube along with the same volume of substrate.

The tubes were placed in a water bath at constant temperature.

One tube was removed from the water bath every five minutes and the concentration of substrate remaining was measured.

These results were used to calculate the rate of reaction during the five minute period before the removal of each tube. The reaction rates are shown in the table.

Tube	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Time period (minutes)	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40
Reaction rate (mg ml^{-1} min^{-1})	24	24	24		0	0	0	0

(a) (i) Apart from temperature, what **other** factor would need to be kept constant? [1]

.....

(ii) How would this be achieved? [1]

.....

(iii) How could the enzyme molecule be affected if the other factor in (i) was not kept constant? [1]

.....

(b) The concentration of substrate after 15 minutes was 360 mg ml^{-1} and after 20 minutes it was 300 mg ml^{-1}. Calculate the missing value for the reaction rate under D and show your working. [1]

.....

(c) (i) At the start of the experiment was the enzyme concentration

greater

less

the same

when compared to the substrate concentration?

(Circle your choice.) [1]

(ii) Explain your choice. [2]

.....

.....

(d) The substrate concentration was doubled and the experiment was repeated. All other factors were kept constant.
In the open boxes on the table fill in the reaction rates you would expect to see. [3]

(Total 10 marks)

33.

(a) (i) By means of a simple labelled diagram indicate the structure of a triglyceride (fat) molecule. (Detailed biochemical structure is not expected). [2]

(ii) Name the bonding involved in the formation of a triglyceride. [1]

.....

(iii) Give **two** differences between the structure you have drawn and a phospholipid. [2]

.....

.....

.....

.....

(b) Suggest **one** reason why animals tend to store energy in the form of fat rather than carbohydrate. [1]

.....

.....

(c) What is the difference between a saturated and an unsaturated fat? [1]

.....

.....

.....

(d) An experiment was carried out to find the effect of the enzyme lipase on the fat in milk. 10 cm^3 of full cream milk was mixed with 0.5 cm^3 of sodium carbonate solution and three drops of universal (pH) indicator. Universal indicator changes colour as shown below.

1 cm^3 of unboiled enzyme was added to one tube (A), 1 cm^3 of lipase was boiled, cooled and added to a second tube (B). The milk, sodium carbonate and indicator solution was divided between the two test tubes. The tubes A and B were then incubated at 35 °C for 3 hours.

(i) Suggest why sodium carbonate was added to the tubes? [1]

.....

.....

(ii) What colour would you expect in tube A after 3 hours incubation? [1]

.....

(iii) Briefly explain your answer to (ii). [2]

.....

.....

.....

.....

(iv) Explain why no appreciable change in colour was observed in tube B. [2]

.....

.....

.....

.....

(Total 13 marks)

Essays

1.

(b) What are immobilised enzymes? Describe the advantages of their use and how they are used in biosensors. [10]

2.

(b) (i) Describe how inhibitors affect the rate of an enzyme catalysed reaction. [7]

(ii) Describe the advantages of using immobilised enzymes in industrial processes. [3]

3.

(a) Describe the biological principles involved in the use of immobilised enzymes including the detection of blood sugar using biosensors. [10]

4.

(b) Describe and explain how different factors affect the rate of enzyme catalysed reactions. (Effects of enzyme inhibitors are not required.) [10]

5.

(a) Describe and explain the effect of inhibitors on enzyme action. [10]

6.

(a) Define the term "enzyme" and relate its function and properties to its structure.

7.

(a) Describe the structure and function of enzymes. Explain how their activity is influenced by pH, temperature and inhibitors. [10]

8.

(a) (i) Explain what is meant by enzyme inhibition and describe how the various types of inhibitors function. [5]

(ii) Using a graph, explain the effect of a fixed concentration of each type of inhibitor on the relationship between substrate concentration and the rate of an enzyme catalysed reaction. Assume that inhibitor concentration is lower than enzyme concentration. [5]
(Graph paper is not required)

9.

(a) Describe the structure of an enzyme molecule and explain how the properties of enzymes are related to this structure. [10]